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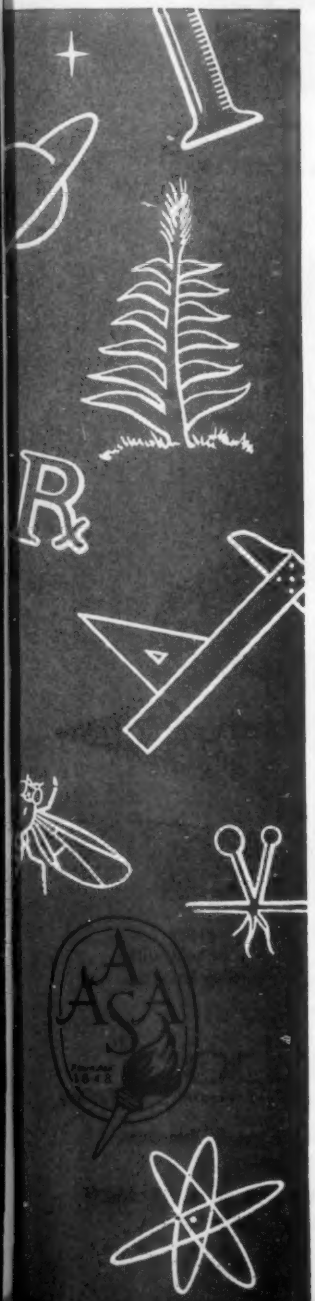

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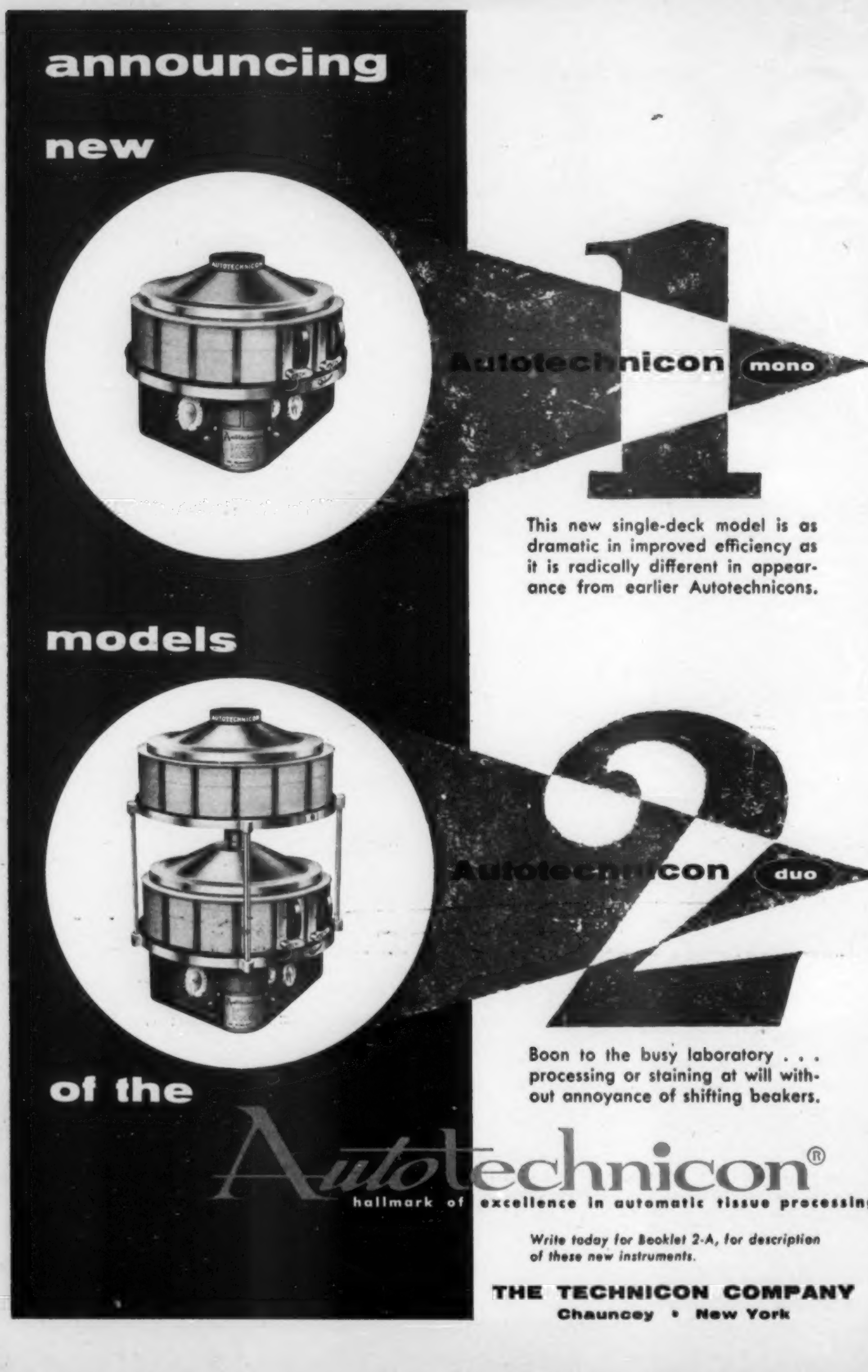
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Government, Industry, the University, and Basic Research

The following three articles—by Paul E. Klopsteg, Monroe E. Spaght, and Kenneth S. Pitzer—are based on papers given by the authors in the symposium Roles of Government, Industry, and the University in Basic Research *held in Berkeley, California, 30 Dec. 1954, as part of the annual AAAS meeting.*

Role of Government in Basic Research

Paul E. Klopsteg

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TWO conferences that considered government's role in scientific research have been held within the past 2 years. The first, the 7th Conference on the Administration of Research, met late in the summer of 1953 under the sponsorship of the University of California and held a symposium at Berkeley. The general theme of the symposium was the common interests and relationships in research among industry, universities, and government. The second conference, also held at Berkeley, was the meeting of the Industrial Science Section of the AAAS, the theme of which was the roles of government, industry, and the university in basic research. The two conferences discussed similar subjects but the second limited its concern to basic research.

Of basic research there are many definitions. I venture to suggest still another, better suited to the present article* than any I have found. The concept "basic research" may comprise the systematic endeavor, without preconception, to increase our knowledge and understanding of nature. It is the kind of research that some of our colleagues characterize as "pure science." If it is indeed pure, it derives that quality from uncompromising objectivity, unconcern over specific aims, and absence of intent to exploit results. It is intellectual adventure: a hunting expedition in unexplored domains where the weapons are the experimental devices and aids to observation by which data are gathered, processed, and made ready for interpretation. The trophies of the hunt are new concepts and principles. They are freely shared, through publication, with all who are interested in them.

For the most part, basic research is conducted by scientists on faculties of colleges and universities. Much research that is sometimes called basic is carried on within government-owned and government-operated as well as industrial laboratories. Such research may lack the afore-mentioned purity because it gets an occasional nudge, or at times even a strong push, in the direction of the practical interests of the supporting agency or industry. But it is difficult to separate the kind of research under my definition from all that appears under the category "basic," for example, in the National Science Foundation's study *Federal Funds for Science*. This study shows that government funds in amounts of $116 million, $120 million, and $131 million have been obligated in fiscal years 1953, 1954, and 1955, respectively. The figures are valid in that each reporting agency had its own interpretation of the term *basic research* and submitted its figures accordingly. If the suggested definition could be applied precisely, the quoted amounts would undoubtedly undergo a drastic downward revision.

Whatever the extent of such reduction, the annual amount applied by the Government to basic research is now many times greater than it was prior to World War II. Much progress has evidently been made in persuading those individuals who act for government in providing or denying funds to agencies that basic research is important in the national interest, and that it is a proper function of government to support such research. It is the "defense in depth" for both our economic development and the national defense.

As we consider and discuss basic research, we should be aware of the fact that basic research and education are inseparable, especially research and education in the graduate schools of our universities and colleges. The importance of increasing the numbers of scientists and engineers has been the subject of much discussion in recent months and of intensive study within the executive branch of the Government. Hence the importance of the teaching function of our institutions of higher learning can hardly be overappraised. The competent research professor probably contributes as much as or more, in the long run, through the education of his graduate students than he does by his own research. Under his direction the students make appreciable contributions to knowledge in their research. Moreover, the total amount of good research that can be conducted is limited by people,

* The opinions expressed are my own. They do not reflect the official views of the National Science Foundation.

B.P.

not by dollars. It is clear also that applied research and development depend for further progress upon essentially the same kind of education that prepares students for basic research. There are many examples of physicists and chemists who in an emergency of war became excellent engineers; and there are instances of industrial scientists and engineers who have successfully reentered the academic community.

It is not my intention to dwell at length on the responsibilities of the National Science Foundation, an executive agency of government, for the support of basic research and education in the sciences. The NSF Act of 1950 assigned such responsibilities, and others. The provisions of the act constitute national policy with respect to basic research. They have been further clarified in Executive Order No. 10521, which is also an expression of national policy. One section of the order states:

> As now or hereafter authorized or permitted by law, the [National Science] Foundation shall be increasingly responsible for providing support by the Federal Government for general-purpose basic research through contracts and grants. The conduct and support by other Federal agencies of basic research in areas which are closely related to their missions is recognized as important and desirable, especially in response to current national needs, and shall continue.

There is ample provision in the law and the executive order to justify strong and increasing support by the Government of basic research and to make certain that no single agency becomes monopolistic in such support. No doubt some of the research carried on by the service agencies, in conformity with the executive order, is basic in the sense of our definition. No one, I am sure, disagrees in the present circumstances with the policy of increasing the nation's basic research under government subsidy, for we recognize the need for greater effort in research. Until something better may appear, the policy statement quoted may be generally approved.

Clearly, it is quite impossible within the scope of a short article to deal with the many aspects of government's role in basic research. A simple way to present a summary of sorts would be to give many more figures showing the extent and direction of government involvement in basic research. Such a presentation could be misleading; for dollar figures, as a measure of research in the various sciences, are not an accurate or comparable measure of the work that is going on. In different fields, research costs differ widely. A much better measure would be scientist-months, and an effort ought to be made to develop a suitable way of basing comparisons on time devoted by competent scientists to research in their respective fields.

Since government is already deeply involved in basic research, it would be academic at this point to argue that it should or should not be so involved. But we may properly discuss whether more or less government money should go into basic research. Is it possible to devise a better policy? Can the role of government be altered in a desirable way? This is a large question. It deserves examination. In response to the question "Why is government involved in basic research?" I have an answer from one of the speakers in the 1953 conference. He said, "One can say without reservation that the underlying motivation of the Government in science is the utilization of science." If this appears to be in conflict with our definition, we may take note that if basic research requires justification, it is justified by the experience that new knowledge of science has great potential value to society. Such value comes from eventual utilization. At any rate, this is the argument that must be made to bureaus and legislative committees to justify budgets and appropriations.

The arguments are familiar. When we consider science and technology during the past 150 years, we have conclusive evidence that progress in practical utilization depends on ever-increasing knowledge and understanding. We cannot utilize what we do not have. The risk capital that has supported basic research through the years has paid off handsomely. In the long run, the results benefit every citizen; they are therefore in the national interest, and public funds should pay the cost.

Indeed, it is not impertinent to ask why, in a country that takes great and justifiable pride in private enterprise, more of the financial support for basic research should not come from private sources and correspondingly less from government.

Many of us, I am sure, are somewhat unhappy at the possibility that government funds without foreseeable limit must be provided for basic research. Inseparable from basic research is the kind of higher education that produces research scientists. I should be much more content to see large annual funds from private sources carrying the major costs of research and of the training of scientists. If the policy of constantly increasing government subsidy were unassailable, we should soon be heading for a welfare state in science and education, with all basic research and most educational costs subsidized by the Government.

To travel this road without limit must be not only questioned but opposed on at least two grounds. First, when funds come easily and in large amounts, as they usually or frequently do from government, the concomitant is likely to be free and easy spending and finally deterioration in the quality of the research. More important is the looming, disquieting vision of annual funds requiring nine figures to express, supplied and administered by the Government, in the indefinite future. Does such a vision make you uneasy? It should; for it requires only scant imagination to picture therein a bureaucratic operation that would irresistibly and inevitably take a hand in the affairs of our institutions of higher learning. If this should happen, how could freedom from domination by "empire builders" in government be maintained?

There appears to be only one possible method of blocking such a trend. Here is an important role in basic research for enlightened government: to devise

ways and means by which vastly larger funds are made to flow to our institutions of higher learning from a great diversity of sources. Funds should come not only from corporations but from the great number of private citizens who are potential donors to such causes.

No one would take issue with the statement that our universities and colleges suffer a chronic form of anemia which consists of a deficiency of dollars in the financial bloodstream by which budgets are maintained in balance. Much thought has been devoted to the financial needs of higher education, and many words have been written on this question. Efforts are being made to obtain more money from corporations and, to a lesser extent, from individuals, with a measure of success. It is heartening to note that corporate directors increasingly see the dependence of our economic progress on the output of our colleges and universities. At best, however, the total of such funds can, in the foreseeable future, cover only a small fraction of what the institutions need. Moreover, the maintenance of a steady flow of funds from industry demands a great effort in annual solicitation.

The rapid increase in college enrollment and its prospective doubling within a dozen years deeply concerns the college and university administrators. They recognize that now is the time to prepare for the deluge.

A great potential source of funds, aside from the corporations, is the private citizen—every citizen whose income would logically make him a contributor to worthy causes, such as higher education. It is here, in the tapping of this source, that government can play an exceedingly important role in the support of basic research and education. Only government can bring about a large yield of funds from this source. It can do this by making it possible for the individual to give, at nominal or no cost of giving.

Let me make clear what I have in mind. There are some millions of income-taxpayers whose tax computation involves the surtax brackets. Those in the highest brackets are able to contribute at the lowest cost. For the relatively few in the maximum bracket, the cost is $90 per $1000 given, since the tax rate is 91 percent. Thus, if one of these select few donates a deductible $1000, it saves him the $910 in tax that he would pay if he did not make the donation, hence the $90 cost. As we move downward in the surtax brackets into the lesser incomes, where the number of taxpayers is vastly greater, the cost of giving steadily increases. For example, the cost in the 20 percent maximum bracket would be $800 per $1000. This is incentive in reverse, a deterrent. That it has proved so is clear. Individuals have not been rushing forward with their gifts. Total deductions for gifts are only a small fraction of permissible amounts, for both individuals and corporations.

Obviously it would be fairer and more realistic if a positive incentive could be established, and if it could be made sufficiently compelling to induce adequate giving. Incentive would be maximum, obviously, if the cost of giving were entirely eliminated. It would still be great if the cost were kept small. It points to the necessity for revising those portions of the income-tax law that pertain to charitable donations. They should provide either that cost of giving be the same for all or that cost be related to ability to give. In either case, costs should be substantially reduced below present levels.

Several methods come to mind for accomplishing this desirable end. Details would have to be worked out by tax experts. In making the suggestions, I recognize that objections to them can and will be raised. The way around them must be found; for the fact cannot be overemphasized that we have the choice of only two courses. Either we take the simple and easy way and let the Government pay the cost, accepting with it the threat of government domination of research and education; or we insist on the maintenance of freedom and initiative for our institutions of learning. If, in trying to achieve the second choice, there is an alternative to obtaining the funds from a great diversity and number of private sources, I am unaware of it.

Of the three methods that I have to suggest, the simplest would probably be that of permitting the taxpayer to make his deductions not from taxable income but from the computed tax. Limits would have to be set for the amount given, and these would require occasional study and revision to bring about the desired results. The method would put all taxpayers on the same basis with regard to cost of giving: there would be no cost.

A second method, following established practices more closely in form, would comprise adding a new surtax bracket to the existing ones—an arbitrary "highest" bracket into which donations that are now deductible would fall. If in this bracket the surtax were 100 percent, and the "spread" of the bracket were made great enough to include all deductible items, the cost of giving would be zero. Limits would have to be set for the amounts that might come within such a bracket, and a percentage figure would have to be chosen between, say, 95 and 100 for the applicable surtax rate.

A third method—possibly the most promising with respect to the possibility of revising the tax statutes—would be to continue the present rules for computing the tax but to make the allowable deduction from the tax base a multiple of the donation. The multiplying factor would have to be determined with the stated objective of providing strong incentives to giving, and with ability to give as one of the factors.

It may be supposed that with sufficient incentives for corporate and individual givers, our institutions would be quickly provided with all the money they need, for both educational and research functions. This would, of course, depend on the details of the tax provisions. One would anticipate, however, that these would be meticulously and conservatively drawn with a view to careful experimentation with the method chosen and with the idea of modifying them in the

direction of increasing the incentive if this should appear necessary.

One other important fact should be kept in mind. Probably the Government will have to continue to support certain areas of basic research, apart from the support that adequately financed institutions would provide for the researchers on their faculties. As we all recognize, a great change in the pattern of basic research occurred during World War II. Team research, the new phenomenon, was largely unknown before 1940. Most of the work financed by OSRD was applied research, but it was carried on primarily under contract with educational institutions by their scientists. Funds were ample to finance the most intensive creative activity of this sort that had ever been known. Among other things, it demonstrated how a sense of urgency among research workers can produce results otherwise impossible.

After V-E Day the urgency diminished, and after V-J Day it disappeared. The thousands of engineers and scientists engaged in this strenuous work were eager to return to the quiet of their laboratories, to resume the academic life and the more leisurely pursuit of their interests. But life for them could not again be the same. Many had seen team research on a large scale and had participated in it. They saw its applicability to many basic problems as well as to applied research and development. To them the "kilobuck" had become the monetary unit in expenditures for research. The team research they saw ahead is exemplified in the great accelerators of ever-increasing energy, which have annual costs for equipment, supplies and maintenance, and which require budgets for operating and scientific personnel greater than the total prewar budgets of many institutions. In such undertakings it seems impracticable, if not impossible, for a single institution or even a group to finance the operation out of regular current funds, even if these were greatly increased by means of the afore-mentioned revisions of income-tax laws. As science advances, there will be more and greater need for team research, in the biological as well as the physical sciences. There seems little doubt that the costs must be paid out of government grants or contracts. Moreover, to the extent that government agencies carry on basic research in their own laboratories, there will be government financing.

In summary, it is clear that the Government has a present important role in supporting basic research by providing funds for the conduct of such research in the laboratories of its own agencies and, in emergencies, for the procurement of research and development services from nongovernment agencies. It must also make grants and contracts under which educational institutions may support the work of research scientists on their faculties. Government also has a present responsibility with respect to increasing the numbers of qualified research scientists. Prospectively, government will have to finance indefinitely the large projects of team research that involve annual budgets quite in excess of the financial resources of any institution.

Beyond this, government has a role affecting basic research that goes beyond current practices and procedures. Serious threats of government domination arise from unlimited increases in the flow of government money to educational institutions. The trend can be stopped and reversed only if the government devises ways and means, through changes in the income-tax laws, that will result in the direct major support of institutions through gifts from large numbers of corporate and private donors. This would keep research free and improve its quality; and it would substantially reduce the severity of, or indeed eliminate, many problems that have their origin in the inadequacy of funds for higher education.

Basic Research in Industry

Monroe E. Spaght
Shell Oil Company, New York

THE total area of research is broad. Its boundaries, as well as those of what we call basic research, are not very distinct. Even within the central regions of basic research there is less than perfect agreement on what should be done, and how, and why. I can best define the subject in fairly general terms; and I can best describe it by pointing to certain broad questions that are common to most programs of basic research in industry.

In the interest of clarity, let us consider basic research in industry from three points of view: (i) its place—that is, its relationship to the larger scene of scientific inquiry; (ii) its problems—not a category of projects, but a review of some general questions that may help to delineate the main features of basic research in industry; and (iii) its promise—a few comments on the past achievements of basic research and its possible contributions in the future.

Place. Research has been called the systematic, intelligent treatment of problems for which the data or methods needed for solution are either unsatisfactory or lacking. Such a systematic, intelligent inquiry can be carried on in any field from science to human relations. There are many unsolved problems in all

fields. A great deal of research is being conducted, some by colleges and universities, some by research institutes, some by government laboratories, and some by industry. All told, perhaps 450,000 researchers are working in the United States, and more than a third of them are professionals; that is, they have at least a bachelor's degree in one of the pertinent curriculums.

I hardly need to add that investigation on this scale is costly. The rate of expenditure for research by industry, government, and universities is more than $4 billion a year. Industry accounts for a large part of this money. Indeed, it has been said that the general use of technically trained people as organized teams for solving scientific and engineering problems is the most distinctive feature of our industrial development in the last 25 years. One recent study indicates that of the total research expenditures in the United States, about 65 percent, or $2.5 billion, is spent in industrial research laboratories. However, not all this came out of industry's pocket: $1.4 billion came from company funds and $1.1 billion came from government sources. The industry programs employ more than one-third of all the people engaged in research.

Such figures indicate that a substantial effort is going into various kinds of research, but how big is the effort compared with some of the other parameters of the business supporting it? A survey of 1450 companies in 26 lines of business showed that company-financed research ranged from 0.1 to more than 5 percent of gross sales income. Leather, lumber, and food industries are on the low side of the group. Drug, instrument, and chemical industries are high. But percentages based on net sales can be misleading, because of the great difference in profit margins among the various industries. In the drug industry the research expenditure, which is only 4.4 percent of sales income, is 38 percent of net profits. In the food industry, which has a lower profit margin, research expenditures amounting to only 0.2 percent of sales income are 10.6 percent of net profits.

It appears, then, that it is not easy to "place" research, even with respect to something as concrete as company financing. Low-profit margins make even low research budgets look big. High profits after taxes make big research budgets seem smaller.

Probably the best way to pin down the cost of research in any given situation is to look at the cost per man, and here we find rather striking uniformity from company to company and from industry to industry. Research costs per man range from about $7000 a year to roughly $10,000 a year.

In considering costs per man, we must remember that these figures are for total manpower and that the ratio of professional to nonprofessional workers varies considerably. In terms of professional workers, research costs per man are much higher; the middle range runs from about $15,000 to $25,000 a year.

So much for the big picture. To see where basic research fits into the scene, we should consider the main kinds of research being carried out in industry. I use the term *main kinds* because there is little agreement on the precise division of effort or on the names for the various divisions. One widely accepted description allows for four categories. A new book lists and describes in considerable detail some 23 categories of activity bearing the name *research*. For my requirements, I suggest three categories. We have pure research, which I define as the inquiry after knowledge for its own sake, without consideration or hope of practical gain. We also have applied research, the investigation carried out in response to immediate, direct, and obvious needs. Basic research is in between.

By basic research, then, I mean the scientific inquiry carried on, not under pressure of immediate needs or in hope of quick profit, but with reasonable hope of some eventual payout. It is research conducted to broaden the base of knowledge in any field that interests the companies supporting the research. It may use the knowledge, tools, and methods of pure research, but it rests on a different philosophy. It knows generally what it wants to learn, and it stops at the edge of its chosen field—where pure research would run on.

It is a kind of inspired curiosity, maintained by staffs totaling 10,000 men and women, of whom 4000 are professionals. It has reached such stature that top management in American industry is betting more than $100 million a year that this curiosity will yield something worth while. This sum is roughly one-tenth of the total expenditure by industry for research in the United States. It is spent in support of work both in industry-operated laboratories and in other laboratories, such as those in colleges and universities.

Altogether, industry spends about $10 million a year in support of research in universities and other nonprofit institutions. This sum is all spent for pure and basic research and does not include instructed research, graduate fellowships, or other grants of money for programs directed more toward the training of future scientists than toward the discovery of new knowledge. I stress this to show that the selfish interest that industry must take in advancing science is tempered. Shell Oil Company is a good example. We are now maintaining a program of 20 research grants, costing about $200,000 a year, which we give to departments in leading universities throughout the United States. The research grants are awarded for the support of current work in fields of science and technology, but there are no restrictions on the direction of work or on the publication of results, and the individuals who receive the awards are under no obligation to Shell. In addition to these, we are supporting specific research being carried out by professors of chemistry and chemical engineering in three universities. These men are working on problems of their own selection; to us it is basic, to them it is pure. All of these aids to university research are separate from our current program of 50 graduate fellowships in engineering and the physical sciences.

Another example of the support of university re-

search by industry is the $730,000-a-year program for research on petroleum sponsored by the American Petroleum Institute and conducted in various university and government laboratories. The information produced by such studies is too general to answer any immediate needs or to give anyone an edge in competition, but all the information is of long-range value to the petroleum industry, and the member companies willingly support it.

It is, perhaps, not too extreme to describe the industrial scientist in basic research as a man imbued with a chaste spirit of scientific inquiry and a good sense of double-entry bookkeeping. The basic researcher is no more in business for his health than the sales manager, although the pressure on him to show a quick profit is not quite the same.

Yet, despite the lack of pressure, the movement in industry toward more elaborate programs of basic research has been remarkable. Even though we knew 20 years ago that the great technologic advance in industry would require a great deal of research, we could hardly have predicted then that industrial concerns would today be sponsoring a program as large as the one I have just outlined—and my own opinion is that we have seen only the beginning.

This has happened for a very good reason. It has paid off. It will continue only so long as it continues to pay off. Although altruistic reasons may be involved in some programs of basic research, and although industry is increasing its support of study aimed at the long-term social benefit of all mankind, it must be understood that when we talk about basic research in industry today we talk about an undertaking that is made primarily for the economic advantage of the sponsoring agency.

Problems. The first concern of anyone planning to conduct basic research is to decide as nearly as he can what he wants to do and how he will do it. This leads to a consideration of certain general questions, and in these we can discover—perhaps better than anywhere else—some of the essential features of basic research in industry.

Why does industry want new information? To us who have grown up in a society whose philosophy is constant change, this question seems easy to answer. If we were vintners in Bordeaux we would probably be reluctant to make an overt effort to find new things, but if we are marketing gasoline in California we can be sure that what is enough knowledge today will be inadequate tomorrow. The new knowledge may ultimately manifest itself as an improved product, a better process for making today's product, or, what is perhaps the most likely, a new item on the company's list of products. It may result then in keeping the company competitive in a changing technical environment, in increasing profit through improved operations, or in expanding the scope of the corporate activities through new ventures.

Are the problems of an industry ones that research can solve? Although it is true that research must begin with a problem, it is also true that not all problems are suitable for research. Some problems can be answered only by individual taste or prejudice. And some problems lead to solutions that are indeterminate or not reproducible. For example, a businessman trying to decide whether to apply for accelerated depreciation on a new plant has a problem. But he cannot solve it by research. The answer, which depends on conditions that do not yet exist and which cannot be predicted on the basis of past experience, is indeterminate.

What are the scientific possibilities for successful research in an industrial field? In the organic chemical industry, for example, there are so many fields eligible for further study that a large company that has no unbreakable ties to any raw material or product could support a very large amount of research, which on the average might pay off. Yet, the mere existence of a problem that seems eligible for solution through research is still not justification for work. Methane might be made to yield higher hydrocarbons, but I doubt that one would underwrite research in methane behavior unless one had some completely new ideas about methane. Here, it seems to me, is one of the hardest tasks of the industrial research scientist—to assess the chances of obtaining useful new information through exploration of an enticing area of ignorance. It may be an area never before trespassed by the brain of man or it may be an area trampled over countless times. There may be new weapons at hand, but they may prove to be poorly adapted to the terrain of the conquests. Even after the campaign has been decided upon and the march is begun, probably nowhere in man's activity does he come to so many choices of path where there is such a premium on alertness and even on intuition. Industry's demands on the brains of its scientists are not light.

I have cited the chemical industry as one that presents many areas seemingly eligible for basic research; here a critical program of selection must exist. In many industries, however, the limit is set low by the number of ideas worth looking into.

This limited situation must be distinguished from another that sometimes besets the research scientist in an industry that actually has good opportunities for research. This is the case in which only the scientist can see the opportunities. His trouble lies in convincing management to allocate funds for study. There is no pat solution for this problem. The natural divergence of interests between research and management is part of the play of forces that gives vitality and a certain air of democracy to most successful organizations. Success goes to the group whose management is best able to find and maintain a dynamic balance. One scheme for reaching this healthy tension is to reach into the research group, pluck out an experienced scientist, and put him on management's side of the conference table. His subconscious then works for research, but his conscious thought, forged hard by the endless blows of reports on sales and overhead, tempers his eagerness for new horizons through research.

I should point out also that having the opportunity to find new knowledge and fulfilling these rigorous qualifications still are not enough justification for industrial research. The research should not be conducted if the findings do not have some chance of paying off on the investment. However, our scientists generally have intelligent hunches about their chances of finding something that will ultimately be worth while. Let me illustrate with an example or two from the area of applied research. If a chemical process gives undesirable yields of side products, the trained chemist can predict quite well whether the side-products might be reduced under other processing conditions or whether the operation could be improved only through some very difficult or costly procedure. A good engineer can predict quite well his chance of success in slowing the rate of deterioration in a certain piece of equipment or whether, by using new and better instrumentation in a certain operation, he could reduce the labor required to do the job. Although my examples come from the area of applied research, I believe that, after all other tests have been passed, there are still bases for judging the value of the new information that can come from the basic research.

Assuming that there are areas of interest suitable for research and that there is reasonable chance of obtaining new knowledge that will be useful, can a company executive assure the board of directors that something good will result from the research? The answer is *No.* No matter how able the scientists may be, how well equipped the facilities, how diligent the staff, one can never guarantee results. If there is anything certain about research it is this—and I include pure, basic, and applied research in this confident generalization—not all efforts will succeed, some successes will never make a profit, and nothing is sure until the work has been done.

How does industry decide how much to spend on a program of basic research? In the case of applied research, there are some well-accepted yardsticks to use in answering this question. These yardsticks generally relate to the ability of the sponsoring company to use the results of research. For example, there is no point in developing more processes than a company can commercialize. Money to build the plants, the technical ability to operate them, and the management talent to control them are needed—and do not underestimate the last two, for they are definite limitations.

With basic research, however, one is inclined to say that these limitations do not apply and that we should study only those things that have fulfilled the requirements of being eligible and subject to reasonable prospects of utility and will make the corporate entity feel that it is being a good citizen in its industry and its society.

As I have said, the limitations on the amount of basic research are most likely to be set by the number of worth-while ideas that the scientists of an organization can propose. If, however, the number of eligible areas is unlimited or very large, then one can apply the same kinds of limits that prevail with applied research—there is no business reason for following a program of research beyond what can be consumed and utilized by the sponsoring organization. Just as with applied research, there is a relationship between the effort and the amount of capital and management attention that must be dedicated to its utilization. Thus a large chemical company would not devote to basic research more than it could hope to utilize by the application of an appropriate development and capital-expenditure program. Beyond such consideration of the relationship of basic research to development and application, any further investment in search for new knowledge would have to be based on altruism or some longer range program of contribution to society that falls beyond the justification usually sought in a business enterprise. An attempt to relate investment in basic research to the specific parameters of the development and capital abilities of an isolated company requires that the investment be large enough to play on the laws of probability. It is obvious that a single venture in basic research can yield nothing; alternatively, it could by chance yield such a wealth of new ideas that the corporate facility for its application would be completely inadequate. This problem becomes less important, the larger the organization, and it disappears completely in a venture the size of the American economy.

I presume that some expect me to explain away the much-discussed imbalance in America between basic research and application. I support the general contention that Americans have excelled as utilizers of, rather than contributors to, knowledge—and there are reasons for this that demand no apology—and perhaps I must agree also that a greater investment in search for new knowledge is necessary if our present rate of technologic advance is to continue. Let me point out again that industry is supplying an increasing amount of support to this search, particularly to universities and their affiliated research institutes. I believe that this support from industry will continue to increase.

Promise. The rewards for research can be very great indeed, and it is in them that we find our hope of promise for other rewards to come. The way so far is marked with some remarkable achievements, some famous, others obscure. But all are important.

The immediate results of basic research are seldom very spectacular. They do not get into the headlines, they do not directly change the lives of millions or result in enormous savings or gains or victories or defeats—not in themselves. But in their long-term effects they may do all these things. The history of science is studded with examples. I shall mention only a few.

Certainly one is the story of Langmuir's work in the General Electric laboratory years ago—the first industrial research unit of its kind in the United States. Langmuir, who is responsible for the modern incandescent lamp with its tungsten filament and gas filling, laid the foundation for this invention by means of a series of experiments made for the purpose of

studying atomic hydrogen. The subject was related to a field in which G.E. was interested, but Langmuir had no thought of improving lighting when he began his work. Indeed, he said: "At the time I made these experiments, they would have seemed to me useless if my prime object had been to improve the tungsten lamp." Yet as a result of this venture in basic research, the replacement of the old carbon filament lamp with the tungsten filament, gas-filled lamp was estimated to be saving the public more than $2 billion a year as early as 1930.

Another story, of intermediate age, but of similar stature in industry, concerns a young instructor in chemistry at Harvard, W. H. Carothers, who was hired by Du Pont to begin a program of basic research in organic chemistry. He chose as his subject the study of polymerization by condensation and the structure of substances of high molecular weight. In 1928 he began the study of condensations in which linear polymers are produced—and this led eventually to nylon.

More recently the Solid State Research Group at Bell Telephone Laboratories conducted some basic research on the electric properties of semiconductors. This work, which was really an outgrowth of some contract research on crystal rectifiers that Bell and other industrial and academic laboratories had carried out during World War II, led the research group to the transistor—a revolutionary development in electronics.

These examples show us the potential rewards of basic research. Other, quiet results, known only to those in the field concerned, can also be important and can, in their way, contribute just as much to the advancement of science and the betterment of standards of living.

I mention briefly, in this connection, some work in free radical chemistry done a few years ago by Vaughan and Rust and their colleagues at Shell Development Company. These men wanted to know more about the high-temperature substitutive chlorination of propylene to yield allyl chloride, a reaction that had been discovered by others in their group. The discovery of this reaction, which was contrary to the teachings of classical organic chemistry, had been made in the course of a basic exploration of the field of hydrocarbon chlorination; it was the basis for the world's first synthetic glycerin plant. However, when this plant began operation, a totally unexpected side-reaction began to occur at a totally unexpected place in the process; it threatened for many days not only to shut down the plant but perhaps to require some redesign with attendant capital cost and lost operating time. But this group of scientists had learned enough about the basic mechanics of the reactions involved to come up with a means of controlling the formation of the undesirable side-product. Few people know about this contribution, yet it has made possible a steady supply and a stabilized price structure for one of the most important chemical building blocks in industry.

There is another side to this story of basic research, the part about those who do not conduct any. So long as the competition conducts none, nothing much happens. But if your competitor studies his science and broadens the base of knowledge, sooner or later he will know some things you do not know. And then you are in trouble. For a long time, virtually all the methanol used in this country came from the wood-distilling industry, a tidy little operation that yielded a nice profit and required no great effort. Management cooked wood, sold the product, and failed to conduct research. Meanwhile some German chemists were working hard on the chemistry of carbon monoxide and some other related matters in organic chemistry. One day they announced that they had found a way to make synthetic methanol. An American chemical company heard about this and decided to put the German company to the test. They ordered some of the product, not just a little quantity for analysis, but enough to challenge the German company's productive capacity. They ordered a tanker of methanol. It was delivered. The wood-distilling business was dead.

Then there is the poignant and rather common case of the scientist who conducts basic research or is aware of it and yet does not appreciate what the studies disclose. This situation points up the necessity of carrying out enough basic research of your own—and of knowing about the research efforts of others—so that opportunities or challenges will be recognized as they come along. Bichowsky, in a diverting little book entitled *Industrial Research*, tells of the time he attended a lecture by William Ramsey, the discoverer of argon, neon, krypton, and xenon. Ramsey said that these gases were so inert that they would not combine with anything and hence were useless scientific curiosities. Then, to show that the gases were pure substances, he displayed a series of gas-filled glass tubes arranged so that a discharge of electricity could be passed through them. "All pure substances," he said, "are characterized by the fact that they give out, under an electrical discharge, their own special kind of light." He turned on the current. The five tubes lighted up with a pale glow, each tube a different color. "Under different conditions of discharge," he said, "these colors can be intensified." He then switched a condenser into the line, and the tube containing neon flashed up a brilliant orange-red. It was very striking. Everybody applauded and went home. Not one of the 500 or so persons who saw the demonstration realized that he had seen the first neon sign.

It is easy to look at the recent and very rapid growth of research in industry and to ask whether this may not be a fair-weather operation, conducted at relatively low cost to the stockholder in a time of high profits and high taxes. One might be tempted to suggest that if business sags a bit, research may be sharply curtailed. But the handling of research budgets in recent years suggests that most companies will be more intelligent in their administration. After all, many large research programs can be curtailed only

at a serious cost in lost momentum. Further, as competition stiffens, it becomes more important to maintain or increase the advantage that comes with more thorough knowledge. Therefore it seems quite safe to assume that industry's expenditures for basic research will continue to climb. If there is any delay in the development of research, one of the most likely causes will be the scarcity of technically trained people. They are not coming out of colleges and universities as fast as our society needs them. Industry and education can do the nation a service by encouraging young people to study science, to ground themselves well in fundamentals, and to make careers in scientific work. Few endeavors are more satisfying, and few are more needed in the world today.

The opportunity and necessity for basic research continue as research increases knowledge. There can be no turning back. Man's best hope of gaining wisdom, the better to manage his knowledge, lies in gaining still more knowledge of himself, of the world he lives in, of the materials he works with, and of the processes by which he changes them.

Companies spend money on research with hope of eventual profit. This hope rests on the certainty that profit comes only from service to society. Basic research, which broadens industry's knowledge far beyond its immediate goals, has served us well in the past and is serving us magnificently now. We have no choice but to foster its growth for still greater service in the future.

Role of the University in Basic Research

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IF we take the usual meaning of basic research as contrasted with applied research, then we can say at once that the role of the universities is to perform a large portion of the basic research and to train virtually all the men engaged in research. Most of the basic research has been conducted in the universities in the past, and I believe that this should and will continue to be the case. The mission of the university is to create and transmit knowledge. This aim is parallel to the aim of basic research; consequently there is no possible conflict of purpose when basic research is carried out at a university.

Other organizations usually have very different principal aims, such as making and selling gasoline, generating atomic power, or making atomic weapons. In many cases such organizations conduct effective basic research related broadly to their other aims; this is to be encouraged. However, there always comes a point at which the basic knowledge seems to have too little relationship to the principal business. Thus it is best if a very active basic research activity exists under auspices that set no artificial boundaries.

From another aspect the university offers the ideal setting for research. The strongest human driving force in basic research is curiosity. H. L. Mencken wrote:

> The value the world sets upon motives is often grossly unjust and inaccurate. Consider, for example, two of them: mere insatiable curiosity and the desire to do good. The latter is put high above the former, and yet it is the former that moves one of the most useful men the human race has yet produced: the scientific investigator. What actually urges him on is not some brummagem idea of Service, but a boundless, almost pathological thirst to penetrate the unknown, to uncover the secret, to find out what has not been found out before. His prototype is not the liberator releasing slaves, the good Samaritan lifting up the fallen, but a dog sniffing tremendously at an infinite series of rat-holes.

This story illustrates very well the driving force, the human driving force, that leads the scientists, in their search for basic knowledge and explanation of basic phenomena, to work long hours and with great enthusiasm. Students have this curiosity and aid effectively in the search. And one reason why much basic research is best handled in the university framework is because the focus on curiosity is the primary aim of the institution as well as of the individual. At the same time the university certainly does not ask for a monopoly on basic research. There are many nonteaching basic research units that have their place and that have made remarkable contributions—indeed contributions that would not have been feasible in universities. Examples are the Carnegie Institution of Washington and the Mount Wilson Observatory.

I think those of us in universities would agree that it is desirable for various sorts of laboratories with applied aims, whether government or industrial, to be active in basic research to the extent that seems wise within their general framework of operation. I am sure it contributes to the effectiveness of the industrial laboratories and applied government laboratories if a certain component of their work is of a strictly basic character, and if it is made clear to the individuals concerned that they may follow their investigations almost without restriction wherever they lead. Nevertheless, it seems clear that the major responsibility for a flourishing program of basic research lies with the universities; it is from this point of view that I wish to continue my discussion.

I am not going to comment at length on the importance of basic research. I think that most scientists

are in agreement on this question. But I am concerned with the question of how the effectiveness of the university in basic research can be maintained, improved, and extended. As is not uncommon, the subject turns in considerable measure to money. One of the big problems of universities today, and one of the problems we expect to be even more stringent about 10 years hence, when student enrollments are expected to be about twice those of the present, is the provision of adequate funds and facilities for university activities. These include in very large measure research of a basic nature as well as the teaching or the transmitting of knowledge.

It is a matter not only of getting an adequate amount of money into the university's operation but of handling this amount of money in a fashion that does not hamper the basic character of the work. In other words, the funds that finance research should be available in a manner that does not restrict the operation of the investigator, who should not be continually concerned with the question: "If I follow this lead in this direction, will I be getting into an area where the source of financial support will no longer be appropriate?" The funds for university research can best come from what I would simply call normal university budgets, that is, from the same general budgetary framework that includes the salaries of the members of the professorial staff and their nonprofessorial assistants as well as the funds for chemicals, or materials for the machine shop or the glassblowing laboratory, and so forth. In this method of financing nothing has been said about the subject of investigation other than that it is in the botany department or biochemistry department or the physics department. Therefore, obviously, there is no limitation on the subject or method of investigation.

Unfortunately, however, the usual university budgets are inadequate even for the present level of basic research, and they have had to be supplemented by funds from various grants or contracts, which in turn have tended to put one boundary or another on the manner of use. The aim ought to be to increase the amount of money coming through regular channels in university operations rather than continually to multiply the varieties of routes through which these funds arrive.

During World War II, the Federal Government supplemented research funds in the universities to a very large extent, mostly for military work. In the period since the war the problems have become more basic, but the mechanism of government support is still very similar. Let us consider two general sorts of activities. First, there is the research of a professor and several graduate students, equipped with what might be called ordinary instruments and equipment. Here government contributions are not very large. In most circumstances the greater expenses are actually still being carried through usual university budgets. But even in this area, research would be seriously hampered if the relatively moderate supplements coming from government sources were not continued. On the other hand, there are some very expensive types of research going on at the present time that are of great importance to basic science as well as to various applied sciences.

One of the major examples of this second type is the Radiation Laboratory at the University of California. Certainly the advances in the understanding of the properties of atomic nuclei would never have been made at the rate and with the effectiveness that they have been made without some major establishments of this sort. The use of cyclotrons, synchrotrons, linear accelerators, and, in other locations, atomic reactors, and so forth, is obviously impossible unless there is a substantial organization that can handle the construction and operation of these machines and thus make them available for the scientist in his more immediate experiments on the properties of nuclei. I would certainly not raise any questions about the necessity and appropriateness of government financing for these expensive ventures. I think the Government, by and large, has developed methods of financing these operations that are about as satisfactory as one is likely to find.

What means can be used to supplement the regular current university funds for the first type of research activity? As I have indicated, a professor and a few graduate students and possibly a postdoctorate fellow are usually concerned. In some cases there may be two professors collaborating or a slightly larger number of assistants but still no unusually large expenses. At present there are in this area an enormous multitude of small grants and contracts. I think the term *grant* is certainly preferable; it is used within government circles whenever the law permits it. But, in organizations such as the ONR and AEC, contracts are written in a form that, within the general government framework, allow a maximum degree of freedom in the operations in the university. What are the effects of this large number of relatively small grants or contracts and the small sums of money that go along with them on university operations?

Before answering this question, I would like to mention that this is not the system that is being followed in Great Britain. I have had the pleasure of discussing the problem of supplementing the finances for university research with a number of leading British scientists, and they have told me in general about the British University Grants. A certain sum is set aside for university research in the government budget and then the University Grants Committee decides how much of it goes to Oxford, London, Manchester, Cambridge, and so forth. But at the governmental level it is not necessary to decide how much Professor X at Cambridge, Professor Y at Oxford, and Lecturer Z at Manchester, and so forth, are each to receive. The problem is handled on a much broader basis, and the essential effect is that the funds are put into the usual university budgets insofar as the investigators in the various laboratories are concerned.

I have discussed this problem on a number of occa-

sions with men in the National Science Foundation, in particular with Alan Waterman when the foundation was getting into operation. I expressed the hope that the foundation, since it did not have any boundaries in terms of scientific fields of applicability, would find a broader and less restrictive mechanism for assisting university research than the sort of individual contract that had been necessary for the ONR and AEC. The latter agencies have an essentially applied science character and therefore must consider the applicability of a given subject of investigation to their field. I understand the reasons that apparently led the NSF not to establish a broad new route. As I understand it, the foundation believed that it was politically impossible to take a lump sum of money and decide how much each university, college, technical institute, and so forth, ought to receive on a lump-sum basis, whereas the same result could be accomplished by breaking it into 10 times as many pieces and distributing them in terms of the subjects of investigation and the individual investigators. I certainly appreciate this problem and would not want to assert that the decision was wrong, but I do assert that this small-project method is troublesome from the point of view of the university and that we ought to try to replace it in the future.

There are many troublesome restrictions involved in this project type of distribution. The investigator, in preparing a proposal, naturally asks himself, "What sort of proposal is most likely to be approved?" Even though the government agency has no intent to restrict the field of investigation, the investigator will naturally be thinking not only of his scientific interest but also of what is most likely to be approved. More serious, I think, is the tendency of an investigator, after he has presented a detailed proposal and had it approved, to feel obliged to continue it. I am sure most agencies do not intend this to be restrictive. They almost invariably approve requests for a change in the subject of investigation. But there is an element of inertia here, an element of uncertainty on whether the change would meet favor or not, which tends, indeed, to restrict the freedom of the work to a certain extent.

H. W. Dodds, president of Princeton University, has, I think, sensed this difficulty. In an article in *Physics Today* [7, 4 (1954)] he coined the term *projectitis* and defined it as

> . . . an unhappy addiction to limited objectives. Perhaps at the very moment at which the individual should be broadening his own comprehension and deepening the knowledge of his discipline with freedom for roaming speculation in an atmosphere unencumbered by the pressures of problem solving commitments to external agencies.

This is a thing which, as I say, many of us have sensed without any particular complaint at any particular action on the part of any government agency.

Curt P. Richter, of Johns Hopkins University, writing in *Science* [**118**, 91 (1953)], discussed "Free research versus design research" and noted that there is a tendency to examine too closely the proposals for research grants in terms of the plan of research that was offered. If it is truly basic research, there should be a minimum of emphasis on the plan. The investigator should be free to change his plan from day to day as the subject unfolds, because he has no fixed objective in terms of a particular practical problem to be solved. If he commits himself in developing a detailed design, he is doing something extraneous to his real purpose. A senior investigator with an established reputation can request a broad scope and give little or no plan, but the junior investigator without an established record of past accomplishment finds it difficult to obtain acceptance of an unrestricted proposal.

An event that occurred at a recent meeting of the chemistry panel of the NSF illustrates this point clearly. The question was raised: "Should a chemistry professor in a particular university be allowed to have two NSF grants or projects at the same time?" The panel's reaction was that something was wrong with the breadth of definition of the first project if he wanted a second project. The remedy recommended was to write a broad subject of investigation for this particular project so that the second field of study would be included within the authorization. Then, as a second and distinct action, one might consider whether the total dollar amount of the grant should be increased or not. Here was a case where the subject of investigation in the grant had been written far more narrowly than the research interests of the individual called for. When this is true there is inevitably a restriction upon the character of the scientific investigation. This particular problem can be straightened out, but it indicates the weaknesses and the dangers of the system. It is the system itself that disturbs me, not the administration of the system, which I think has been sincere and effective in practically every government agency.

In addition, these numerous small projects present an administrative burden. Various individuals write proposals; their department chairmen review them; the central administration of the university reviews them; the proposals are then sent to the government agency; the agency has other scientists in other locations referee them; the section chief of the agency makes recommendations; his superior reviews them; eventually the responsible official of the agency gives the final approvals. Next the contract or grant is written; possibly the university business manager objects to it; there is further negotiation, and so forth. In other words, there is a lot of administration for each individual sum of money. I am very happy to see that the NSF has chosen to adopt a relatively standard form of grant with a minimum of business details; nevertheless, the scientific reviewing remains.

Whether it is feasible for the Government to use a different type of distribution I do not know, and I am not recommending any immediate change. I think that the Government should see to it that university research is adequately financed, not necessarily that the

Government finance it directly. If steps can be taken to cause adequate funds to flow into university channels from private sources, this will be far superior to an attempt to modify the government method of support of research in order to overcome these objections. There will still remain the larger projects that need the Government's attention; it might be better to keep the government activities in that sphere. Some industrial funds have been supporting research in a manner that has been very effective; on the other hand, some industrially sponsored research in universities should probably not have been put in a university at all. I do not mean that industrial activities in this area are better or worse than those of government; I mean simply that the best of the industrially sponsored activities are excellent and should serve as models for further expansion.

The foundations, of course, have had considerable experience in handling the support of research with a minimum of restriction. The tradition of a foundation is to say "once we have made you a grant, you go ahead and spend it as you see fit."

On the industrial side the Du Pont Company, to mention one, has been making some general grants in chemistry in recent years that are completely unrestricted with regard to the manner of expenditure. In other words, the funds can be incorporated with other departmental funds and used in whatever fashion seems appropriate and necessary. A relatively moderate addition to the number of general grants of this type would alleviate many of the difficulties involved with government projects and, in fact, would alleviate the need for the smaller government projects.

I hesitate, without more study than I have been able to give, to mention a dollar sum, but it seems to me that this could be estimated relatively easily by looking at the total magnitude of small grants from all such agencies as the NSF. I believe about $20 million per year goes into relatively small grants in the natural sciences. This is a very small proportion of corporate profits. If industry were to distribute this sum in an unrestricted fashion, and if the sum were divided on some reasonable basis among the various universities, the investigators in the smaller, less expensive types of work would be free from the necessity of applying for special funds and from all the concern and possible restrictions that I have mentioned.

This is a challenge that American industry ought to consider very seriously. Does not the solution to this problem lie in this line and at an expense that would not look large from the point of view of the entire scope of American industry. I might also comment that funds that are made available to universities on this broader basis are, I am sure, used very much more efficiently. Once a research grant has been broken down into small units as a matter of direct negotiation with the Government, there is an obligation, either to spend it within the bounds of that original project or to allow it to revert. If the money came to the university on a broader basis, the plants for expenditure could be rearranged if new needs arose and new developments occurred. This would yield a much more flexible basis that would provide much greater efficiency of utilization. I have estimated, as a matter of fact, that the $10,000 per year which the Du Pont Company gives the chemistry department of the University of California is more important for research purposes than $20,000 to $30,000 in the small grants that are tied to specific subjects of investigation and cause various difficulties in their use.

The natural effect of all government aid to research has certainly been helpful. I do not know what the universities would have done in this period had these government funds not been available. I think the administration by various government agencies has been excellent. My critical comment is strictly about the system that breaks down the funds into very small units that are tied closely to particular subjects of investigation. I hope that both government and industry can contribute to improved methods in the near future.

News and Notes

Pacific Division 1955 Meeting

The Pacific Division of the AAAS will hold its 36th annual meeting at the California Institute of Technology, Pasadena, 20–25 June. The Division includes members in California, Oregon, Washington, Idaho, Montana, Utah, Nevada, British Columbia, and Hawaii.

Twenty-six scientific groups will have sessions in the following fields:

Astronomy: *Astronomical Society of the Pacific*, contributed papers, 21, 22 June.

Chemistry: *American Chemical Society*, Southern California Section, symposium on "Free radicals," 21 June.

General: *Federation of American Scientists*, Los Angeles Branch, symposium on "International exchange of scientific personnel and ideas," 23 June. *Southern California Academy of Sciences*, contributed papers, 21 June.

Geography: *Association of Pacific Coast Geographers*, contributed papers, 20, 21 June; field trip, 22 June.

Geology: *Geological Society of America*, Cordilleran Section, symposium in two parts: (i) "Trace elements in igneous and sedimentary rocks and in deep sea sediments," (ii) "Metamorphic problems," 23 June.

Mathematics: *American Statistical Association*, symposia on "Quality control," "Applications of electronic computers," and "California's population: a study in dynamics," 23 June. *National Science Foundation*, symposium on "The theory of numbers," 22, 23, 24 June. *Bio-*

metric Society, Pacific Northwest Division, symposia on "Genetics," "Psychometrics," and "Ecology," 22, 23, 24 June.

Meteorology: *American Meteorological Society*, contributed papers, 21, 22, 23 June.

Physics: *Section B. AAAS*, symposium on "Cosmic rays and high-energy particles," 21 June.

Psychology: *Western Psychological Association*, symposium on "Psychological and biological effects of stress," 24 June.

Biology: *American Nature Study Society*, contributed papers, 21, 22 June; field trip, 23 June. *American Phytopathological Society*, contributed papers, 22, 23 June; symposium, 23 June; field trip, 24 June. *American Society for Horticultural Science*, contributed papers, 21, 22, 23 June; symposia, 22, 23 June; field trip, 24 June. *American Society of Limnology and Oceanography*, contributed papers, 22, 23 June. *American Society of Plant Physiologists*, contributed papers, 21, 22, 23 June; symposia with *Botanical Society of America*, "Photosynthesis," 22 June "Active absorption by cells," 23 June. *Botanical Society of America*, contributed papers, 21, 22, 23 June. *Cooper Ornithological Society*, contributed papers, 22 June. *Ecological Society of America*, contributed papers, 21, 23, 24 June; symposium, 22 June; field trips, 23, 24 June. *Herpetologists League*, contributed papers, 21 June. *Pacific Northwest Bird and Mammal Society*, contributed papers, 22 June. *Society of American Bacteriologists*, contributed papers, 24 June. *Society for Experimental Biology and Medicine*, contributed papers, 21 June. *Society of Systematic Zoology*, contributed papers, 20 June. *Western Society of Naturalists*, symposium, 23 June.

Visitors are urged to complete registration on the opening day, 20 June. Caltech will hold open house on the first afternoon of the meetings to welcome visitors and display its research facilities. Thirty-three commercial exhibits, grouped around a central refreshment area, will also be open.

Excursions on the various days of the meeting will go to Southern California points of scientific interest: the Mount Wilson and Palomar Observatories; the Los Angeles State and County Arboretum, Arcadia; Rancho Santa Ana Botanic Garden at Claremont; and the Henry E. Huntington Memorial Library, Art Gallery, and Botanic Gardens in San Marino.

A special feature of the meeting will be three invitational lectures dealing with "Ideas: their genesis, support, and communication." On Tuesday, 21 June, Linus Pauling, chairman of the division of chemistry and chemical engineering at Caltech and 1954 Nobel laureate in chemistry, will speak on "The genesis of ideas." On the following evening Dean Rusk, president of the Rockefeller Foundation, will consider "The support of ideas." Finally, on Thursday evening, Will Burtin, designer and visual researcher, will analyze "The communication of ideas." All three lectures will be delivered at 8 P.M. in Sexson Auditorium, Pasadena City College. The general public is cordially invited to attend.

Housing reservations should be sent directly to the hotel desired, accompanied by a deposit for one night's lodging. Accommodations are available at: Huntington-Sheraton Hotel (10-min drive from the campus), double or triple rooms $4.50 per person per night; Constance Hotel (walking distance from campus), double room $3.50 per person per night, single room $5; Green Hotel (10-min drive from the campus), double room $3.25 per person per night, triple room $3; Caltech Student Houses (men only, no private baths), single room $3.50 per person per night, double room $3.50, triple room $3, small double (bunks) $2.75; for motels, write to California Motel Association, 2131 East Colorado Street, Pasadena.

A campus lounge and social center and a trip to TV City, Los Angeles, are being planned for women guests. Information about things to do and see in Southern California will be available at the registration desk.

Further information may be had by inquiry to AAAS Convention Office, California Institute of Technology, Pasadena.

Science News

The U.S. Atomic Energy Commission has invited state governors to send representatives to a **conference to discuss the health and safety** aspects of regulations applicable to users of source, special nuclear, and by-product materials. The commission announced in April that it has approved three proposed regulations under the Atomic Energy Act of 1954 that cover production and utilization facility licensing, special nuclear material licensing, and the safeguarding of restricted data. In the preparation of the proposed licensing regulations, the commission gave extensive consideration to health and safety aspects of licensing, such as the qualifications of the applicant to engage safely in the proposed activities, the adequacy of his equipment, and the suitability of the location at which he proposes to engage in the activities for which he seeks a license.

The commission is preparing regulations to establish the standards that it will require licensees to observe. These rules will prescribe maximum permissible limits of radiation exposure and will establish requirements concerning radiation monitoring, radioactive waste disposal, and related matters.

The Swedish Government intends to propose, probably in collaboration with other countries, a United Nations study of the immediate and long-range biological **effects on man of nuclear explosions.** In a statement to the Riksdag in early May, Foreign Minister Osten Undén referred to the study that is under way in the United States. He observed that the problems involved require an international investigation under U.N. auspices.

A **National Selective Service Scientific Advisory Group** has been established within the Selective Service System to advise the agency's director regarding scientific problems that confront him. Members of the new group are Leonard Carmichael, secretary, the Smithsonian Institution, chairman; A. V. Astin, director, National Bureau of Standards; Detlev W. Bronk, president, National Academy of Sciences and National

Research Council; Carlton S. Dargusch, Committee on Specialized Personnel, Office of Defense Mobilization; Jerome C. Hunsaker, chairman, National Advisory Committee for Aeronautics; Francis W. Reichelderfer, chief, U.S. Weather Bureau; Lewis L. Strauss, chairman, U.S. Atomic Energy Commission; Alan Waterman, director, National Science Foundation.

A new scientific and technical **documentation center** established by the Egyptian Government and UNESCO in the National Research Council office in Egypt is being guided by three experts who performed a similar service for Mexico. Augusto Perez-Victoria, Spanish scientist who headed UNESCO's mission to Mexico, is chief of the new center. Cosby Brinkley, an American who organized the Mexican microfilm service, and Julio Garrido of Spain, formerly editor of the bulletin of the Mexico center, are carrying similar responsibilities in Egypt. These men are among some two dozen UNESCO technical-assistance workers who have already completed missions in other countries and are on their second or third assignments.

The Mexico City center is now in the hands of an all-Mexican staff trained at the center through UNESCO technical-assistance fellowships. This staff abstracts material from 2000 scientific periodicals each month; its information services are used by scientists and manufacturers throughout Latin America.

Canada, Japan, and the United States will join forces this August to conduct an oceanographic **survey of the North Pacific Ocean** from North America to Japan and from the Tropic of Cancer almost to the Bering Strait. Plans for Operation NORPAC, as the program is called, were announced by Roger R. Revelle, director of the University of California's Scripps Institution of Oceanography, during the recent annual meeting of the American Geophysical Union.

The results are to serve as a background for studies of fisheries problems of all three countries, and to provide data for exhaustive research in the various fields of oceanography: physical, biological, chemical, meteorologic, and geologic. The ocean area to be covered comprises more than 10 million square miles, or about one-sixteenth of the earth's surface. At least 20 fully equipped oceanographic research vessels will be engaged in a simultaneous survey of the region. They will sail a total of about 70,000 mi.

In terms of ships, manpower, and area covered, this will be the largest oceanographic program ever conducted. And in none of the previous large oceanographic cruises have the measurements been taken in a short enough time to avoid inclusion of seasonal changes in the ocean currents in the measurements. Previous cruises have covered large areas but have required more than a year to complete.

NORPAC has been more than a year in the making. Three United States agencies are involved: the California Cooperative Oceanic Fisheries Investigations, using the vessels of the Scripps Institution and the South Pacific Fishery Investigations of the U.S. Fish and Wildlife Service; the department of Oceanography of the University of Washington; and the Hawaii-based Pacific Oceanic Fisheries Investigations of the U.S. Fish and Wildlife Service. The Canadian agency is the Pacific Oceanographic Group, Nanaimo, B.C. The cooperating Japanese agencies are the Nagasaki Marine Observatory, the Kobe Marine Observatory, the Hakodate Marine Observatory, the Japanese Hydrographic Office, the University of Hokkaido, the Tokai Regional Fisheries Research Laboratory, the University of Fisheries, Toyko, and the Central Meteorological Observatory.

Joseph L. Reid, Jr., oceanographer at Scripps who has worked as coordinator of the various plans, stated:

> The most significant feature of the program is that for the first time we will be able to view the entire North Pacific current pattern without any disturbances due to seasonal changes, which have made our previous pictures so difficult to understand.

The 16 May issue of *Time* contains an article on **Lee A. DuBridge**, president of California Institute of Technology. The article points out that

> The tradition of "pure" science is a foreign one that had to be transplanted from Europe and virtually forced on American soil. Even today the nation spends, through the Government, $2 billion a year on science, but only one dollar in 20 goes to pure science. The U.S. has more than 850,000 scientists and engineers, but only about 3% are engaged in fundamental research. The reason for the imbalance is that 1) such research seems dreamy and impractical, and 2) there are tremendous demands for scientists to work in technological fields, both military and commercial. Pure science, explains DuBridge, is "not the development of new devices or techniques. It is not the discovery of new cures for diseases. It is not the development of new weapons for war." Pure science is "simply knowledge."

The article discusses the breakdown of barriers between disciplines and quotes a C.I.T. alumnus as having said:

> When I was an undergraduate, I majored in biology. But, of course, Caltech's biology is really biochemistry. Now everybody knows that chemistry is only a branch of physics, but it took me until my senior year to realize that physics is a branch of philosophy.

The article then describes DuBridge's observation that it is tragic that the goals of science are so little understood, that science is regarded either as in a mysterious category of its own or merely as a producer of bombs and security risks.

> You would think that the fate of the world rested on the outcome of some sort of race between scientists, on the one hand, and all the historians, philosophers, writers, economists, poets, preachers and political and social scientists on the other, with the implication that if science wins, the human race will be blasted to oblivion. . . . Are science and engineer-

ing just the tools for man's amusement and for his ultimate destruction? Let us say, rather—and more truthfully—that they are his . . . tools in his eternal struggle to achieve his highest . . . spiritual ends.

Work on the new **Pacific Research Laboratory** at Chicago Natural History Museum is nearing completion. The laboratory, which will be a center for Pacific anthropological research, already contains some 10,000 ethnographic specimens from Polynesia, Micronesia, Melanesia, Australia, Indonesia, the Malay Peninsula, Madagascar, and the Philippines. It will include a storeroom, workroom, and poison room and will make available for research and reference one of the world's most important collections in its field. The material included has been accumulating since as far back as the 1890's.

Cooperating institutions, in addition to the Natural History Museum, include the Wenner-Gren Foundation for Anthropological Research in New York; the Philippine Studies Program that is financed by the Carnegie Corporation of New York and conducted by the University of Chicago; and the Newberry Library (Ayers Collection) of Chicago. Evett D. Hester is in charge of the project.

The Department of Defense and the Atomic Energy Commission announced on 17 May that the **underwater explosion** of a small nuclear device in the eastern Pacific Ocean had been successfully completed by Joint Task Force 7. The indications are that the test involved no health hazard to mainland or island inhabitants or to consumers of fish. The Scripps Institution of Oceanography participated in the test, for which it had conducted extensive preliminary studies. The explosion was scheduled in order to obtain information that is essential to the development of tactics for antisubmarine warfare.

Scientists in the News

The 1955 Hoblitzelle agricultural awards for outstanding research contributions to American farming have been won by two scientists of the U.S. Department of Agriculture and one from the Texas Agricultural Experiment Station. These awards, established by the Hoblitzelle Foundation, are administered by the Texas Research Foundation of Renner, Tex.

Sterling R. Olsen, USDA soil scientist, who is stationed at Fort Collins, Colo., and who works with the Colorado Agricultural Experiment Station, has won the $5000 Hoblitzelle National Award in Agricultural Sciences for development of a new, reliable method for estimating the amount of soil phosphorus available to plants. The test is based on use of a water solution of ordinary baking soda to dissolve the phosphorus from a soil sample. It can help farmers avoid applications of phosphate fertilizer when they are not needed, or tell them how much to apply when lack of phosphate limits crop production. Especially valuable for use on neutral and alkaline soils common in the West, the baking-soda test is more dependable for a much wider range of soil types than previous methods for estimating available soil phosphorus. It has been adopted by soil-testing laboratories in a number of states and in Turkey, India, and other countries.

Joseph C. Stephens, USDA plant breeder stationed at Chillicothe, Tex., and **J. Roy Quinby,** superintendent of the Texas Agricultural Experiment Station at Chillicothe, jointly received the $5000 Hoblitzelle Achievement Award for Advancement of Texas Rural Life for their development of a practical method for commercial production of hybrid sorghum seed. Their work in providing a genetic method—use of male-sterile plants—for commercial production of hybrid sorghum seed makes it possible for farmers to increase grain-sorghum yields 30 to 40 percent. Farmers of Texas and nearby states will be growing hybrid sorghums in 1956, and yield increases equal to those attained with hybrid corn are expected. Quinby and Stephens have worked together in sorghum research at the Chillicothe station for 30 years.

Wyland F. Leadbetter has been appointed associate clinical professor of surgery at the Harvard Medical School and chief of the urological service at Massachusetts General Hospital. He is also surgeon and chief of urology at Mt. Auburn Hospital, Cambridge, and attending urologist for the West Roxbury Veterans Administration Hospital. He was formerly professor of urology at Tufts College Medical School and had served as assistant in genitourinary surgery at the Harvard Medical School from 1946 to 1952.

E. R. Piore, until recently chief scientist and deputy chief of the Office of Naval Research, Washington, D.C., has been elected vice president of the Avco Manufacturing Corp. (New York) and chairman of its Committee on Advanced Scientific Research. He will coordinate the activities of Avco's recently announced team of scientists in nuclear energy, advanced electronics, guided missiles, and other fields. Current research projects for the group include work on an intercontinental missile and part of the continental air defense program as well as programs related to the corporation's civilian products.

Robert S. Alexander, associate professor of physiology at the Medical College of the University of Georgia, has been appointed chairman of the department of physiology at Albany Medical College, effective 1 July. A specialist in pulmonary and circulatory function, Alexander plans to amplify this area of experimentation at Albany as well as to continue the studies already in progress. He succeeds **Harold C. Wiggers,** who has been serving in a double capacity since his appointment as dean in 1953, and who is withdrawing as department chairman because of his increasingly heavy administrative responsibilities.

Willis Avery Wood of the department of dairy sciences, University of Illinois, received the Eli Lilly award on 11 May during the annual meeting of the Society of American Bacteriologists in New York. He

was honored for his extensive investigations of the carbohydrate metabolism of the bacterium, *Pseudomonas fluorescens*. This organism lacks a complete glycolytic system; glucose is metabolized oxidatively by way of gluconic and ketogluconic acids. Wood succeeded in separating and characterizing a number of the enzymes involved in the oxidative metabolism of glucose.

Norris W. Rakestraw of the Scripps Institution of Oceanography, La Jolla, Calif., for the past 15 years editor of the *Journal of Chemical Education*, will retire from his editorship on 1 Sept. to devote more time to research. He will be succeeded by **William F. Kieffer**, professor of chemistry at the College of Wooster (Ohio), who is now an associate editor. The American Chemical Society's Division of Chemical Education publishes the journal.

Ludwig von Sallmann, professor of ophthalmology at the College of Physicians and Surgeons, Columbia University, and attending ophthalmologist at the New York Presbyterian Hospital, will join the National Institute of Neurological Diseases and Blindness, U.S. Public Health Service, on 1 Aug. as visiting scientist. He will direct and expand the eye research program at the Clinical Center and will continue his studies on ocular neurophysiology and ocular pharmacology. He is now recruiting a research staff for these and other investigations.

Georg von Békésy of the Psycho-Acoustic Laboratory, Harvard University, has received the 1955 Howard Crosby Warren medal for outstanding research in psychology. At the presentation that took place during the recent annual meeting of the Society of Experimental Psychologists, he was cited for "a program of research, imaginatively conceived and rigorously executed, that has made an outstanding contribution to the psychology of hearing."

M. Michael Sigel has been appointed associate professor of bacteriology at the University of Miami School of Medicine. He was formerly head of the diagnostic unit of the virus and rickettsia section, Communicable Disease Center, U.S. Public Health Service, Montgomery, Ala.

T. P. Nash, Jr., who joined the University of Tennessee College of Medicine in 1915, is retiring on 1 July as chief of the division of chemistry to devote full time to his duties as dean of the School of Biological Sciences. He will retain his title as professor of chemistry. His successor as chief of the division will be **John L. Wood**, head of the department of biochemistry.

George W. Corner, vice president of the National Academy of Sciences, has been elected a foreign member of the Royal Society of London. He is director of the department of embryology at the Carnegie Institution of Washington and professor of embryology in the Johns Hopkins Medical School, where his laboratory is located.

Elvin F. Frolik, chairman of the department of agronomy at the University of Nebraska, has been appointed associate director of the Agricultural Experiment Stations. He succeeds **M. L. Baker**, who is now in Turkey as dean of the Nebraska delegation and chief adviser of the university's cooperative program with that country. **F. D. Keim** has been named as temporary chairman of the agronomy department.

Nelson Marshall, visiting investigator at the Bingham Oceanographic Laboratory of Yale University, has been named dean of the College of Liberal Arts of Alfred University. His previous service includes both academic administration and marine biological research and teaching.

Meetings

In cooperation with the University of Wisconsin Summer Session, the **National Science Teachers Association** is presenting its 1955 Science Conference in Madison, 29 June–1 July. The theme of the conference is "Keeping up to date with the content and methods of teaching science." Information on accommodations may be obtained by writing to the University Housing Bureau, 434 Sterling Court.

The Woods Hole Oceanographic Institution has announced a series of six **lectures in physical oceanography** to be given by Gifford C. Ewing of the Scripps Institution of Oceanography, La Jolla, Calif. The lectures will be held beginning 5 July and thereafter every Monday, Wednesday, and Friday at 3 P.M., in the lounge of the institution's laboratory at Woods Hole, Mass.

The lectures will be in the form of vectored group discussions aimed at exploring the usefulness of aerial reconnaissance in the synoptic description of physical processes that take place in the upper mixed layer of the ocean. By consideration of the similarity between this layer and the atmosphere close to the ground, an attempt will be made to relate observed surface patterns to the composition and movement of the underlying water masses, using techniques familiar to meteorology. The method will be applied to studies of upwelling and subsidence, the formation and dissipation of frontal surfaces and convergences, to jets, surface and internal waves, wake streams, tidal flow in channels, wind currents, and turbidity flows. Practical consideration will be given to the advantages and limitations of several types of aircraft and to some operational, observational, and instrumental problems.

The fall meeting of the **Committee for the Scientific Study of Religion** will be held in Emerson Hall, Harvard University, on 5 Nov. The principal theme of the sessions will be as follows. To what extent do the canons of science in regard to conceptual structure and empirical evidence allow definitions of religion which render religion a subject for scientific

study without removing it from its historical context and function? One session of the meeting will be open to papers on miscellaneous themes. Anyone wishing to present a paper should send an abstract to the program committee chairman, Dr. R. V. McCann, Andover Hall, Cambridge 38, Mass., *before 1 Sept.*

Plans for the 1955 **East Coast Conference on Aeronautical and Navigational Electronics,** to be held 31 Oct.–1 Nov., have been announced jointly by the Baltimore, Md., section of the Institute of Radio Engineers and the Institute of Radio Engineers Professional Group on Aeronautical and Navigational Electronics. The conference will be held in the Lord Baltimore Hotel, Baltimore. The technical portion of the meeting will be devoted to the general field of aeronautical and navigational electronics. Interested persons are cordially invited to submit papers for consideration; 150-word abstracts should be sent *no later than 1 July* to Mr. Norman Caplan, Bendix Radio Division of Bendix Aviation Corp., Towson 4, Md.

The **Geophysical Society of Hawaii,** which is also the **Mid-Pacific Region of the American Geophysical Union,** plans to hold a regional meeting in Honolulu 15–17 Nov. It is anticipated that the program for this meeting, which will be held in conjunction with a national meeting of the American Meteorological Society, will deal primarily with various aspects of tropical meteorology, agricultural meteorology, meteorological forecasting, cloud physics, oceanography, hydrology, volcanology, and seismology. For information, communicate with the secretary of the Geophysical Society of Hawaii, Larry Eber, Pineapple Research Institute, Honolulu.

Education

The department of physics at **Florida State University in Tallahassee,** in addition to its regular physics major program, has introduced a new curriculum leading to the B.S. degree with a major in radiation physics. This new major is designed to provide the background for a variety of specializations. The number of prescribed courses has been kept to a minimum in order to permit the greatest possible flexibility. By appropriate choice of electives during the junior or senior year, a student may qualify to work in radiation physics, biophysics, geophysics, chemical physics, or experimental psychology; prepare for executive responsibilities in industrial management; prepare for high-school science teaching, premedicine, pre-engineering; or graduate with regular majors in physics, mathematics, or other sciences.

The **School of Medicine of the University of California, Los Angeles,** has been approved by the American Medical Association's Council on Medical Education and Hospitals and has been admitted to membership in the Association of American Medical Colleges.

A new **Library on Man's Place in Nature** has been established within the main scientific library of the New York University-Bellevue Medical Center. It will be concerned primarily with those aspects of the natural sciences, semantics, and philosophy that bear importantly on man, his evolution, and his significance in the cosmos. It is hoped that this library will serve as an adjunct to scientific and medical training and that it will broaden the perspectives of the present disciplines of the medical curriculum. Helen Bayne, who has been librarian of the Medical School Library since 1929, has been appointed curator of the new library and also archivist and research librarian to the Medical Center.

The affiliation of the **Forsyth Dental Infirmary for Children** and the **Harvard School of Dental Medicine** has been announced. Forsyth was one of the first institutions to be devoted exclusively to dentistry for children, and the Harvard School of Dental Medicine was the first dental school in the United States to be established under university auspices. Through this affiliation the two organizations will collaborate in the care of patients, the teaching of dentistry to graduate and undergraduate students, and the conduct of research.

The third in a series of teaching institutes sponsored by the Association of American Medical Colleges will focus on **anatomy and anthropology.** The first one, held at Atlantic City in October 1953, covered the areas of physiology, biochemistry, and pharmacology; the second one, which took place at French Lick Springs in October 1954, considered pathology, microbiology, immunology, and genetics. The objectives of the institutes are to provide an opportunity for medical educators to discuss important teaching problems, to review current experiments in medical education, to exchange philosophies and experiences, and to make any suggestions that might improve the effectiveness of medical teaching and the educational opportunities offered to medical students.

The 1955 institute will be held at the New Ocean House, Swampscott, Mass., 19–22 Oct. The annual meeting of the association will follow, 24–26 Oct. Attendance at the institute will be by invitation only and will be limited to 125 participants. One teacher from each of the 96 medical schools in the United States, Canada, and the Philippines has been nominated by a committee and invited by the AAMC, and the total group of participants will represent a balance among the disciplines and areas that will be explored.

In preparation for the institute, invitees have collected background information and opinions from their colleagues for the use of committees in planning topics for discussion. The institute will be a working conference, with participants meeting in groups of 10 to 15 for informal discussion. The planning committee for the 1955 institute is under the chairmanship of William U. Gardner, professor of anatomy at the Yale University School of Medicine.

Grants, Fellowships, and Awards

Award of 35 unclassified life science research contracts in the fields of biology, medicine, and biophysics, has been announced by the **U.S. Atomic Energy Commission.** Ten of the awards, each of which is for 1 year, are new projects: three are in the field of biology, six in the medical sciences, and one in biophysics. Twenty-five contract renewals for 1 year were awarded to allow for continuation of research already in progress: 10 of these are in biology, 14 in medical sciences, and one in biophysics.

Cancer, arteriosclerosis, heart disease, and enzyme action are some of the fields of university and hospital research supported by grants from **Lederle Laboratories Division,** American Cyanamid Co. Nineteen grants to researchers in human medicine for the current fiscal year total $108,900. In addition, Lederle has made seven grants to universities and agricultural experiment stations in the field of veterinary medicine totaling $29,831 and 12 grants in human nutrition totaling $28,200.

Louisiana State University has received from the **China Medical Board of New York** a grant of $80,000 to support for 2 years a program of fellowships that will enable teachers of tropical medicine and parasitology in U.S. medical schools to obtain practical experience in these subjects in the tropics. The program will be administered by William W. Frye, dean of the School of Medicine, and Henry E. Meleney, research professor of medicine. It has been inaugurated as a result of a recent survey of the instruction in these subjects in the medical schools and of the qualifications of the faculty members conducting the instruction. This survey indicated that the amount of time allotted to parasitology has decreased only slightly since World War II, but that tropical medicine as an entity in teaching has almost disappeared. The survey also revealed that more than half of the teachers of parasitology have had no experience in the tropics.

The localities in which fellows will receive training during the early part of the program are the San Juan de Dios Hospital, San José, Costa Rica, under the direction of Antonio Peña Chavarría, and the School of Medicine, University of Puerto Rico, San Juan, under the direction of E. Harold Hinman. Fellows will have a brief period of orientation at the School of Medicine, Louisiana State University, before proceeding to the tropics. Seventy-seven teachers from 53 schools have expressed a desire to receive fellowships in the program. It is also expected that some of the experienced teachers in these fields will participate from time to time as consultants and instructors in the tropical centers.

Not more than five fellowships will be awarded for any one period in each tropical area. The first fellowship period will be July and August 1955. Tentatively four fellowship periods are planned for each year with 1-month intervals between periods. Teachers who have expressed a desire for such a fellowship will be given an opportunity to apply for a period convenient for them. Other teachers in U.S. medical schools who are interested in this type of fellowship may secure further information from Dr. Meleney at the School of Medicine, Louisiana State University, New Orleans 12, La.

In the Laboratories

Union Carbide and Carbon Corp. is building new research laboratories at Parma, Ohio. The laboratories, which will be managed by National Carbon Co., will engage in basic, exploratory work, much of it concerned with solid-state physics, investigation and design of materials, and metallic and nonmetallic compounds of carbon as well as analogous compounds such as intermetallics and semiconductors.

Research activities will be directed toward specific end-products only to the extent that such products have their primary origins in the discovery of new and fundamental material-process applications. Robert G. Breckenridge, former chief of solid-state physics, National Bureau of Standards, and head of physics, Office of Naval Research, is head of the new plant.

Midwest Research Institute formally opened its new modern research center in Kansas City, Mo., on 9 May. Several hundred business firms and industrial leaders of the Middle West contributed the $1.25 million necessary for construction of the three-level, 80,000 ft^2 laboratory.

The purpose of the institute is to solve technical problems of business, industry, and agriculture as well as problems of general welfare. During the past 10 years, there have been more than 1500 research projects undertaken by the institute for 600 sponsors. These investigations have been concerned with cancer research, electronic computers, nutrition, ceramics, automation, smog control, and other subjects.

The first element of a proposed reactor center, a nuclear materials test reactor, is to be built by **Westinghouse Electric Corp.** at a cost of $6.5 million. The unit will be used to test reactor fuel elements and other components of atomic power plants under actual operating conditions. It is expected to be in full operation within 2 years. Westinghouse will ask approval of the Atomic Energy Commission to locate the reactor center on the company's 550-acre site near Blairsville, Pa.

The reactor will use highly enriched uranium, obtained under AEC license, as the power source, and water as moderator and coolant. It will be housed inside a vapor-tight steel shell and will have built-in safety features, thus avoiding danger to the surrounding area. The remainder of the reactor center will include a laboratory constructed near the reactor building to handle and process radioactive materials resulting from the reactor tests, general offices, and facilities for heat and power.

Book Reviews

Manson's Tropical Diseases. A manual of the diseases of warm climates. Philip Manson-Bahr, Ed. Williams & Wilkins, Baltimore, ed. 14, 1954. xiv + 1144 pp. Illus. + plates. $12.50.

The new 14th edition of Manson's classic volume on tropical medicine is an extensive revision of the last edition, published in 1950, although the pagination remains essentially unchanged. Like its predecessors, the primary orientation of this edition is to the interests and needs of the clinician, in spite of the fact that 200 pages are devoted to brief expositions of medical protozoology, helminthology, entomology, and relevant laboratory procedures. A short chapter is devoted to DDT, gammexane, and certain other insecticides.

The sections on treatment have been brought up to date to include recent information concerning the treatment of leprosy by the sulfones, the newer antimalarial drugs, and the fields of usefulness of the antibiotics. With regard to the antibiotics, I have the impression that greater caution and conservatism might have been advised and that more emphasis might have been placed on the occurrence of undesirable side effects. In this connection, there is not sufficient emphasis on the potential danger of administering hetrazan to cases of onchocerciasis complicated by ocular pathology.

There are certain omissions that might well have been included in a volume of this authority. There is no mention of the extension of yellow fever into Central America north of the Panama Canal. In the chapter on epidemic louse-borne typhus, it is surprising to find no reference to the possibility of transmitting the infection by dust containing louse feces, no description of the technique of DDT dusting a population for epidemic control, and no reference to DDT-resistant strains of lice. There would not be complete agreement on the fact that aerial photographs can accurately identify and delineate the areas in which scrub typhus may be a hazard. The intradermal test is included among the procedures for the diagnosis of brucellosis without the necessary qualification that a positive reaction merely indicates sensitization and not necessarily active infection. Similarly, in discussions of the complement fixation reaction and the agglutination reaction, the significance of a rising titer rather than an absolute titer is not mentioned. Likewise, in the chapter on schistosomiasis, there is no reference to the usefulness of superficial rectal mucosal biopsy for the diagnosis of especially schistosomiasis mansoni.

In his preface, the editor states that the addition of new material required the omission of certain sections included in previous editions. Prominent among these deletions are many paragraphs dealing with historical backgrounds. This seems particularly regrettable since Scott's classic two-volume *History of Tropical Medicine* is no longer obtainable. This new edition contains an immense amount of valuable and useful information. The index is detailed and permits easy reference. No library on tropical medicine can be complete without this volume.

THOMAS T. MACKIE

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The Nation Looks at Its Resources. Report of the Mid-Century Conference on Resources for the Future. Henry Jarrett, Ed. Resources for the Future, Inc., Washington, D.C., 1954. xii + 418 pp. Paper, $5.

On 2–4 December 1953, a Mid-Century Conference on Resources for the Future was held in Washington, D.C., under the sponsorship of Resources for the Future, a nonprofit corporation financed by the Ford Foundation. Attended by some 1600 persons, it constituted the first attempt since the Conference of Governors, called by President Theodore Roosevelt in 1908, to take stock of the national situation with respect to natural resources of all kinds and to explore the problems that their utilization and conservation will pose for the next 25 years and more. This substantial volume presents the record of this conference.

Prior to the conference, a steering committee for each of the eight sections into which it was divided selected the topics to be discussed, together with discussion leaders, and prepared a working paper that was sent to all prospective participants. This careful preliminary organization contributed greatly to the success of the conference. The printed record contains skillfully edited excerpts from the discussions and the chairmen's complete summaries of the major points developed. Included also are an interpretative introduction by R. G. Gustavson, president and executive director of Resources for the Future; key addresses by President Dwight W. Eisenhower and Lewis W. Douglas, chairman of the conference; a panel discussion of an over-all view of the situation prepared by the Brookings Institution; and addresses presenting different points of view on two broad current issues: "The public lands—who should control them?" and "How much should we depend on foreign resources?"

The conference was held primarily for the purpose of enlisting interest, exchanging views, identifying problems, considering possible solutions, and establishing a better understanding among diverse groups. It took no votes, passed no resolutions, and proposed no programs. It did not, in Douglas' words, "draft any pious and awesome encyclical," but it did make known facts and opinions that will help to guide the thinking and the actions of the people of the United States for years to come.

The Nation Looks at Its Resources is a timely book in an attractive format. It should be widely read, and it should be in the personal libraries of both laymen and professionals with a special interest in the subject.

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Monomeric Acrylic Esters. Edward H. Riddle, Reinhold, New York, 1954. vii + 221 pp. Illus. $5.

The title of this book is misleading unless the word *monomeric* is taken to imply a considerable concern with polymerization. In seven chapters, the author considers the esters of acrylic and methacrylic acids, with emphasis on their industrial importance. Fully one-half of the book is composed of two chapters entitled "Polymerization" and "Copolymerization," whereas, surprisingly, there is no chapter on "Preparation"! This subject is dealt with briefly in the introduction by a mention of the industrial processes. There is, however, a good chapter on "Reactions."

The remainder of the book is devoted to analytic methods, storage and handling, physical properties, and a delightful introductory chapter. The story of the pioneer investigations by Otto Röhm in the preparation and application of polymerized acrylate and methacrylate esters is very readable and of general interest.

The subjects of the several chapters are skillfully introduced in such a way that a reader with only slight acquaintance is first brought up to the level of the presentation. The documentation is extensive and international. This book will be useful to the academic chemist to read once, but it will be of reference value only to the industrial chemist.

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Books Reviewed in THE SCIENTIFIC MONTHLY

June

Science Awakening, B. L. Van der Waerden (Noordhoff). Reviewed by I. B. Cohen.
Galen of Pergamon, George Sarton (Univ. of Kansas Press). Reviewed by D. Fleming.
Béla Schick and the World of Children, Antoni Gronowicz (Abelard-Schuman). Reviewed by W. W. Waddell, Jr.
American Thought, Morris R. Cohen (Free Press). Reviewed by P. B. Perlman.
Psychotherapy and Personality Change, Carl R. Rogers and Rosalind F. Dymond, Eds. (Univ. of Chicago Press). Reviewed by A. T. Dittman.
Pajarito Plateau and Its Ancient People, Edgar L. Hewett; rev. by Bertha P. Dutton (Univ. of New Mexico Press). Reviewed by E. K. Reed.
Thoreau: a Century of Criticism, Walter Harding, Ed. (Southern Methodist Univ. Press). Reviewed by B. C. Hendricks.
The Microphysical World, William Wilson (Philosophical Library). Reviewed by R. B. Fischer.
Sex and Morality, Abram Kardiner (Bobbs-Merrill). Reviewed by D. W. Hastings.
Biological Applications of Freezing and Drying, R. J. C. Harris, Ed. (Academic Press). Reviewed by W. L. Simpson.
Wildcat Strike, Alvin W. Gouldner (Antioch Press). Reviewed by E. Forsey.
Coro-Coro, Paul A. Zahl (Bobbs-Merrill). Reviewed by D. Amadon.
Introduction to Atomic and Nuclear Physics, Henry Semat (Rinehart). Reviewed by W. P. Gilbert.
Atomic Science, Bombs and Power, David Dietz (Dodd, Mead). Reviewed by P. Morrison.
Art in Science: A Portfolio of 32 Paintings, Drawings and Photographs from Scientific American (Simon and Schuster). Reviewed by D. Roller.
Margins of the Sea, Maurice Burton (Harper). Reviewed by J. E. Bardach.
Modern Learning Theory, W. K. Estes, S. Koch, K. MacCorquodale, P. E. Meehl, C. G. Mueller, W. N. Schoenfeld, and W. V. Verplanck (Appleton-Century-Crofts). Reviewed by J. M. Stephens.
The Study of Personality, compiled by Howard Brand (Wiley; Chapman & Hall). Reviewed by R. H. Knapp.
Sailing Aerodynamics, John Morwood (Philosophical Library). Reviewed by S. Ober.
Practical Clinical Biochemistry, Harold Varley (Interscience; Heinemann). Reviewed by M. A. Andersch.
Our American Weather, George H. T. Kimble (McGraw-Hill). Reviewed by C. W. Thornthwaite.
Elements of Statistical Mechanics. D. ter Haar (Rinehart). Reviewed by J. Rothstein.
Numbers: Fun and Facts, J. Newton Friend (Scribner) and *Mathematical Puzzles and Pastimes,* Aaron Bakst (Van Nostrand; Macmillan). Reviewed by P. Rabinowitz.
Elements of Algebra, Howard Levi (Chelsea). Reviewed by H. L. Lee.
Pygmies and Dream Giants, Kilton Stewart (Norton). Reviewed by C. E. Snow.
Flash! Harold E. Edgerton and James R. Killian, Jr. (Branford). Reviewed by E. C. Purdy.
American Men of Science. vol. I, *The Physical Sciences,* Jacques Cattell, Ed. (Science Press).
Freaks and Marvels of Insect Life, Harold Bastin (Wyn). Reviewed by C. D. Michener.
Flowers of the South, Wilhelmina F. Greene and Hugo L. Boomquist (Univ. of North Carolina Press).

New Books

Über Sterine, Gallensäuren und verwandte Naturstoffe. Zweite, stark veränderte und erweiterte Auflage. H. Lettré, R. Tschesche, and H. Fernholz. Enke, Stuttgart, Germany, 1954. 445 pp. DM. 85.
Précis d'écologie animale. F. S. Bodenheimer. Payot, Paris, 1955. 315 pp. F. 1200.
Aux confins de la vie. Perspectives sur la biologie des virus. P. Morand. Masson, Paris, 1955. 171 pp. F. 850.
The Birth and Development of the Geological Sciences. Frank Dawson Adams. Dover, New York, ed. 2., 1955. 506 pp. Paper, $1.95.
Truants from Life. The rehabilitation of emotionally disturbed children. Bruno Bettelheim. Free Press, Glencoe, Ill., 1955. 511 pp. $6.

Technical Papers

Intracellular Distribution of Rat-Liver Arylsulfatase as Compared with That of Acid Phosphatase and Glucose-6-Phosphatase

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It has been reported by Dodgson, Spencer, and Thomas, that the arylsulfatase of rat liver is localized mainly in the microsomes (*1*). These authors used potassium *p*-acetylphenylsulfate as substrate. Roy, employing potassium 2-hydroxy-5-nitrophenyl sulfate (4-nitrocatechol sulfate) as substrate, found that some 70 percent of the sulfatase activity was present in the mitochondria of the mouse-liver cell (*2*). More recently Roy reported that the bulk of the sulfatase (43 to 62 percent) is also present in the mitochondrial fraction of rat liver (*3*).

However, none of these authors has studied the intracellular localization of rat-liver sulfatase as compared with that of other enzymes whose intracellular distribution has been well established. Since it has been reported by de Duve *et al.* (*4*) that acid-phosphatase-bearing granules are different from those containing cytochrome oxidase and require larger centrifugal fields for complete sedimentation, it was decided to carry out separation of cytoplasmic granules according to a new fractionation scheme developed by Appelmans, Wattiaux, and de Duve (*5*). In this fractionation procedure, the cytoplasmic granules are separated into a heavy mitochondrial fraction, a light mitochondrial fraction, and a microsomal fraction.

The livers of 15 hours-fasted rats were homogenized in isotonic sucrose containing $0.001M$ versene and fractionated according to the afore-mentioned procedure. The fractions thus obtained were treated for a period of 2 min in a Waring Blendor, usually after a tenfold dilution with glass-distilled water. This was done to cause complete activation of acid phosphatase (*6*). β-glycerophosphate $0.05M$ adjusted to *p*H 5.5 with HCl and buffered with $0.05M$ acetate was used for the acid phosphatase assays. Arylsulfatase-activity tests were made concomitantly, using a slight modification of the method of Dodgson *et al.* (*7*). Assays were made in duplicate, and suitable controls were always run.

The results of a typical experiment are reported in Table 1, which shows that the intracellular distribution of these two enzymes is completely different. Acid phosphatase is localized mainly in the light mitochondrial fraction, whereas 70 percent of the arylsulfatase activity is recovered in the microsomes. The heavy mitochondrial fraction contains only a negligible amount of sulfatase. A larger percentage of this enzyme is present in the light mitochondrial fraction but is probably due to a greater contamination by microsomes. That the nuclei contained a larger percentage of sulfatase than acid phosphatase is easily explained by the fact that nuclei are more readily contaminated by microsomes than by mitochondria. Furthermore Dodgson *et al.* (*1*) have reported that uncontaminated nuclei isolated according to the method of Wilbur and Anderson (*8*) had negligible arylsulfatase activity.

The localization of arylsulfatase in the rat-liver cell was also studied by comparison with that of glucose-6-phosphatase, which has been shown by Hers *et al.* (*9*) to be a typical microsomal enzyme. The same fractionation procedure was used, except that the heavy and light mitochondrial fractions were centrifuged down together. Glucose-6-phosphatase activity was estimated by the amount of inorganic phosphate liberated at 37°C in the presence of $0.008M$ glucose-6-phosphate and $0.05M$ tris (hydroxymethyl) aminomethane buffer *p*H 6.8. Assays were run in duplicate and suitable blanks were always made.

The results of a typical experiment are reported in Table 2. It is evident that sulfatase and glucose-6-phosphatase are both contained in the microsomal fraction of rat liver, the other fractions being contaminated to the same extent by the microsomes. The reconstituted homogenate was made at the end of the fractionation procedure, by recombining aliquots from the different fractions equivalent to the same amount of liver. This preparation still exhibited some 90 percent of the arylsulfatase and glucose-6-phosphatase activities present in the original homogenate.

The foregoing results therefore confirm the observations of Dodgson *et al.* (*1*) that liver sulfatase is contained in the microsomes.

It was found in this laboratory that 2-hydroxy-5-nitrophenyl sulfate is an unsuitable substrate for the study of the intracelluar localization of rat-liver sulfatase, since no proportionality between the quantity

Table 1. Intracellular distribution of rat-liver arysulfatase and acid phosphatase.

Fraction	Percentage of activity of homogenate: Acid phosphatase	Percentage of activity of homogenate: Arylsulfatase
Homogenate	100	100
Nuclei, washed twice	3.6	6.2
Heavy mitochondrial fraction, washed once	20.6	5.2
Light mitochondrial fraction, wash once	37.0	15.8
Microsomes, unwashed	15.9	72.0
Final supernatant	17.4	3.0
Recovery	94.5	102.2

Table 2. Intracellular distribution of rat-liver glucose-6-phosphatase and arylsulfatase.

Fraction	Percentage of activity of homogenate	
	Glucose-6-phosphatase	Arylsulfatase
Nuclei, washed twice	9.7	9.3
Heavy and light mitochondrial fraction, washed once	12.1	10.9
Microsomes, unwashed	75.4	71.8
Final supernatant	3 2	4.7
Recovery	100.4	96.7
Reconstituted homogenate	87.1	90.6

of 4-nitrocatechol liberated and the amount of enzyme used could be obtained. Roy (*2*) reported similar observations and Maengwyn-Davies and Friedenwald have shown that this nonproportionality is attributable to an endogenous inhibitor, which they have shown to be inorganic phosphate (*10*).

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Olfactometric Method Utilizing Natural Breathing in an Odor-Free "Environment"

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Since 1935, when Elsberg and Levy first described the blast- and stream-injection techniques for measuring olfactory sensitivity in human beings (*1*), their suggestion that prepared stimuli be blown into the nostril(s) under pressure has dominated much experimentation in olfaction. The earlier method of using a sniff has frequently been supplanted by the unnatural one of having the subject suspend his breathing while a substitute "sniff" is blown in. After working with variations of the latter method for some time, I have finally abandoned it for many problems, despite my previous endorsement (*2*). The inability of most subjects to perform reliably, even with long training, was one reason for changing; lack of control over the position of internal mouth and throat parts that affect the volume of air admitted was another; and the extreme artificiality of the situation, which raised the question of generalizing to ordinary breathing, was a third.

No artificial mechanism is as efficient as sniffing in carrying air to the olfactory membrane, and there is no reason to believe that it is necessary to control sniff size if concentration of the gaseous mixture being sniffed is controlled so that the number of odorous molecules available, as well as the volume of inodorous air, can be specified.

In 1921, Zwaardemaker (*3*) described what he called a camera inodorata, an unventilated box of glass and aluminum for use with his olfactometer. The subject, with his head inside the box, sniffed through the olfactometer tube that was inserted into his nostril. Thus, the absolute threshold could be measured in an atmosphere relatively free of uncontrolled odors. A much more elaborate "box," actually two glass rooms called an olfactorium, was described in 1950 by Foster *et al.* (*4*) as providing an odor-free, climatically controlled environment for the whole subject. Although neither of these devices has been put to much use by others, the principle appears sound. Accordingly, I have built a modern camera inodorata, avoiding the tremendous cost and space demands of the olfactorium but still achieving the goal of surrounding the subject's head with continually flowing odor-free air during an experimental session. Instead of using a separate olfactometer to test sensitivity, I simply add controlled amounts of odor to the air in the box; the subject is allowed to sniff at will.

The box, in this case, is made of Plexiglas, and has a top and four walls with an inlet near the upper rear corner of one long wall. Inside dimensions are 45.5 cm long by 35.1 cm wide; the walls are 0.6 cm thick. All inside surfaces are perfectly smooth and entirely Plexiglas, yet the box comes apart completely and easily for cleaning. The bottom is loosely closed with a piece of Pliofilm having a slit down the center to serve as an entrance for the head and an exit for the air. The subject's hair and face (except the nostrils) can be covered with plastic materials to eliminate their odors.

The subject is continuously supplied with pure air at a rate of about 13 ft^3/min, enough to insure that positive pressure always exists inside the box so that other air cannot enter. In an adjoining room, a blower draws room air, previously filtered while coming in from outside, through another filter (*5*) of activated carbon, filterdown, and absolute filter paper (*6*), and propels it into the box through a Plexiglas tube 5.3 cm in diameter that passes through the wall and joins the inlet in the side of the box.

The system for odor production, modified from a previous one (*7*), connects with this system for fresh air supply. Odor control is achieved by the saturation

of a stream of pure air with odor by bubbling the air through odorous liquid, maintenance of the saturated gas at constant pressure and temperature to reach equilibrium, and the release—under very slight pressure—of specified amounts of odorous air whenever desired by means of a combination of valves and an electronic timer. Given these conditions, the number of odorous molecules in any stated volume of gas can be calculated if an acceptable value for the vapor pressure of the odorous compound at 20°C can be determined. The concentration of the stimulus can then be expressed as a stated number of odorous molecules added to a given amount of pure air.

The idea of natural breathing in an atmosphere where amount of odor can be controlled was essentially untried for threshold studies. Experience with it has now shown its success in traditional threshold measurement. Figure 1 shows a curve obtained for one subject for measurement of the difference threshold. The data were collected in three 45-min sessions, with 30 judgments per point, using a modification of the method of single stimuli, as was previously described (*7*). In the standard method, the subject is presented with a number of variable stimuli in random order for judgment concerning intensity without a standard stimulus for comparison. In the present procedure, only one pair of stimuli was used at a time, each pair being equidistant about the same midpoint. The subject was uninformed about the procedure but was given four sample stimuli before each session to illustrate the range of strength he might encounter. About every 30 sec, one member of the pair was added to the pure background air and the subject judged it as "strong" or "weak." If the pair with the largest difference (1.34 and 2.25×10^{17}) is called *A*, the next largest (1.54 and 2.05) *B*, and the smallest (1.64 and 1.94) *C*, the order of the pairs over the 3 days was *AB, CC, BA*. A rest of 1 min, when

Fig. 1. Relative discrimination data, using phenyl ethyl alcohol and a modified method of single stimuli. The method of plotting transforms the original ogive into a straight line by converting the percentages of "strong" judgments (obtained *p* values) to *z* scores.

no odor was added, was given after every five stimuli. Curves of comparable regularity have been obtained in measuring the absolute threshold by the method of limits.

The principal advantages of this type of system are (i) the similarity of the subject's task to normal smelling conditions, as contrasted with the extreme artificiality of the blast injection method; (ii) the ease with which subjects take to the task, which requires no special training; (iii) control of the environment around the subject's head, the only body region directly involved in study of olfactory sensitivity; and (iv) the feasibility of using standard psychophysical procedures since each stimulus is quickly removed by means of the continuous flow of pure air. The method is worthy of consideration for use in studies of thresholds, adaptation, mixtures, and a number of other problems, using any human subject who can understand the simple task, and even using reasonably small animals that can be trained to give an indicator response (*8*).

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Bio-oxygenation of Progesterone by Mushrooms

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In recent years the ability of filamentous fungi to form hydroxyl functions on various steroids and at differing carbon positions of these molecules has been a subject of considerable interest. Details of work involving studies on the class Phycomycetes and the class Fungi Imperfecti have been well summarized by Peterson (*1*).

In this light it became of interest to determine whether a similar enzymatic mechanism could be observed to function among members of the class Basidiomycetes. For this study we have cultured various mushroom species under submerged fermentation conditions, as were first described by Humfeld (*2*) and later extended by Humfeld and Sugihara (*3*). Preliminary results of these studies with some of the various mushroom species are presented here.

Conventional fermentation procedures using a ro-

Table 1. Biomodifications of progesterone by various mushroom species.

Mushroom species	Culture *	Filter-paper chromatography† R_f‡								Infrared spectral modifications of progesterone§
Agaricus campestris	NRRL2334		0.15	0.25	0.41		0.69		2.5	Strong —OH, other changes at 6.1 and 9.0μ regions
Agaricus rodmanii	M21									Weak —OH, $\mathrm{C{=}O}$ at 5.8μ, other changes at 6.1μ
Lepiota naucina	NRRL2368		0.12							Weak —OH
Lepiota procera	M44									Weak —OH, other changes not now identified
Lepiota rachodes	M76	0.04	0.12					1.7		Strong —OH
Pleurotus ostreatus	NRRL2366		0.15			0.50	0.72	1.6		Strong —OH
Cantharellus cibarius	NRRL2370								2.2	Moderate —OH
Armillaria mellea	M6a		0.19		0.38					Strong —OH, new bands 5.8–6.0μ, changes at 6.2μ
Hebeloma sinapizans	M84		0.19							Strong —OH
Tricholoma nudum	NRRL2371		0.16						2.0, 2.4	Strong —OH, other changes at 9.0μ
Lycoperdon umbrinum	NRRL2372		0.10		0.37				2.4	Weak —OH
Morchella crassipes	NRRL2369								2.1	Weak —OH

* M-numbered cultures were kindly supplied by T. F. Sugihara, Western Utilization Research Branch, Albany, Calif. NRRL cultures were obtained through the courtesy of C. W. Hesseltine, Northern Utilization Research Branch, Peoria, Ill.

† Resolved in propylene glycol-toluene, 18 hr at 25°C, spots were detected by ultraviolet scanning, and 2,4,DNPH spray reagent. In some instances small amounts of unconverted progesterone were observed using the solvent systems described by Bush (7).

‡ Rate of movement of steroid/rate of movement of compound "S."

§ CH_2Cl_2 extracts of fermentation beers.

tary shaker unit were employed for the growth of the mushroom mycelia and for the steroid conversion studies. In general, the conditions employed for the conversions paralleled those described by Murray *et al.* (4). In the present work, 30 to 50 mg of crystalline progesterone dissolved in 1.0 ml of methanol was added to the growing mushroom mycelia (48-hr growth) cultivated in 250-ml erlenmeyer flasks containing 50 ml of nutrient broth and 2 percent glucose. After an additional 24 hr of growth, the culture beers were filtered on Whatman No. 1 paper and both the beer filtrate and the mycelia were extracted three times with methylene chloride and were pooled. The solvent was then evaporated to dryness with a warm air blower followed by vacuum desiccation. The recovered steroid residues were then freed of fatty materials by a Girard separation procedure and were examined by paper-chromatographic methods (5) in order to detect the formation of oxygenated products. Further examination of the recovered steroid products by means of infrared spectrometry was performed (6). For this study preparations were dissolved in chloroform at 10-percent concentration and were examined in a Baird double-beam spectrometer equipped with a sodium chloride prism.

The data obtained from the paper-chromatographic and infrared-spectral interpretations are presented in Table 1. It is interesting to observe that, although compounds with similar mobilities are present in the fermentation extracts of several different species, in no instance is the pattern of spots identical. Likewise, it is evident that exposure of the progesterone substrate to the growing mushoom cultures results in the production of a variety of steroidal components with greatly decreased paper-chromatographic mobilities, consistent with the oxygenation of progesterone.

When the fermentation extracts were examined by infrared spectrometry, a large number of the spectra showed the presence of a band at the 3-μ region indicative of the formation of hydroxyl functions in the steroid extracts. A control specimen of heat-killed myeelia failed to provide any changes in the absorption spectrum of progesterone when it was treated under similar conditions.

From the data provided it is evident that the fungi of the class Basidiomycetes can readily perform oxygenation and other biomodifications of steroids. A more detailed description of the isolation and characterization of some of the steroid products is being prepared and will be submitted for publication elsewhere.

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Cultivation of Large Cultures of HeLa Cells in Horse Serum

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In many fields of experimental biology and virology, cultivation of human cells in media containing no human serum is desirable and even imperative. The increasing usage of the HeLa cells (*1*), isolated originally from a patient with cervical carcinoma and usually grown in culture media containing human serum, suggested this strain as a desirable one for an investigation of the possibility of adapting human cells to rapid proliferation in a medium of which the serum component is of heterologous origin. The desirability of this strain was also indicated because it is known that it does not do well in media that contain horse serum rather than human serum.

HeLa cells obtained from a commercial source (*2*) and routinely cultured on media A (Table 1) for 112 days in Earle's T-60 flasks (*3*) served as the source cells for the present study (*4*). One heavy culture growing in a T-60 flask was subcultured into 11 D-3.5 Carrel flasks in medium A (Table 1) on which they had been maintained for 112 days. At the first fluid renewal, 48 hr after subculturing, the cell cultures were subdivided at random into five groups, and these were respectively exposed to the five different medium combinations shown in Table 1. Cultures on medium A served as the control cultures for those on the other four test media. All cultures were maintained at the usual temperature of 37.5°C. Routine fluid renewals of 2.0 ml were made three times a week.

Table 1. Experimental conditions for cultivation of HeLa cells.

Test media	Number of cultures		Medium components (volume %)			
	Ser. 1	Ser. 2	Chick embryo extract (*6*)	Earle's balanced salt	Pooled human serum	Horse serum
Medium A	1	2	20	50	30	0
Medium B		2	20	50	15	15
Medium C		2	20	50	10	20
Medium D		2	20	60	0	20
Medium E		2	20	40	0	40

Twenty-four hours after the cultures were transferred to the experimental media, a dramatic accumulation of debris appeared in the cultures that were treated with media B, C, and E. The cultures in medium A, the positive control cultures, were free of debris; cultures on medium D showed only a minimum of debris. No attempt was made to wash the debris out of any of the cultures.

By 72 hr the population of all cultures on all media appeared to be increasing. There was a lessening of the debris in cultures on medium D. In cultures on media B, C, and E, in spite of the rinsing brought about by the continued routine fluid change renewals, the amount of this debris present did not lessen.

At the end of 120 hr of cultivation of cultures in media B, C, and E the accumulation of debris was so great that the cultures were discarded. Cultures on medium D at this time were sufficiently heavy to require subculturing. This was done by flushing the cells from the surface of the glass, making a cell suspension in fresh media, and reimplanting the culture in new flasks. These freshly subcultured cells on medium D were transferred at the next fluid change to medium E and were routinely maintained on this medium with fluid renewals three times a week. They were thereafter subcultured whenever the proliferation was adequate as judged by microscopic observation. Initially this was about once every 14 days, since proliferation on medium E was slow. After 2 mo the proliferation rate increased markedly. By approximately 60 days on medium E, they were being subcultured about every 7 to 10 days, whereas those on medium A, the control series of the cultures, were subcultured every 7 days. Fifty days later the cultures on horse serum were being subcultured every 7 days also and were definitely proliferating at a greater rate than the cells of the parent strain maintained on media that contained human serum.

Morphologically no differences could be observed between cells in the two media. At the present time the strain in horse serum is being routinely maintained in T-60 flasks; however, the strain is already being cultured in 1-lit shaker flasks (*5*). This strain of cells cultured in horse serum readily and rapidly readapts to cultivation in the medium containing human serum.

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6 April 1955.

Communications

Were the Carolina Bays Oriented by Gyroscopic Action?

C. Wythe Cooke (*1*) has presented an explanation for the ellipticity and orientation of the Carolina Bays that is based on an assumed gyroscopic property of a rotating body of water.

I made an investigation of the effects of the spin of the earth on the particles of water in a spinning eddy at 30°N latitude, the circular eddy being 2 mi in diameter and 100 ft deep and having a water velocity of 4 mi/hr near the shore.

The "deflection-to-the-right" effect, together with the centrifugal reaction out from the center of the eddy, causes the level of the water everywhere near the shore to be approximately 6 in. higher than it is at the center of the eddy. These effects are independent of the depth of the water.

The change in the centrifugal reaction out from the center of the earth, caused by the horizontal velocity of the water relative to the earth, causes the water (in the lockwise eddy) to be less than 1/16 in. higher near the north shore than near the south shore. This difference in level increases with the depth of the water in the eddy.

It appears that all these effects could neither cause ellipticity nor influence the orientation of an eddy, for example, a Carolina Bay. Contrary to Cooke's assumption, an eddy does *not* exhibit gyroscopic action. In an earlier publication (*2*) I pointed out that gyroscopic action is exhibited only by rigid bodies and that an eddy is not a rigid body. However, no solution for the problem was presented. The complete report of this study will be submitted for publication elsewhere.

It seems that my conclusion stated in 1951 still is correct, namely, "A meteorite theory of origin of the Carolina Bays appears to be the least unsatisfactory of all the theories that have been published."

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7 February 1955.

Spectral Emission of Composite Liquid Phosphors

It is well known that mixtures of solute phosphors are, in many cases, more efficient light emitters (in the visible) than either of the constituents alone. Owing to the energy transfer from the primary to the secondary phosphor (present in lesser concentration), the spectrum is shifted toward longer wavelengths. As a consequence, the self-absorption (concentration quenching) is greatly reduced, and hence a higher light output is obtained (*1*). Besides, a better match with the S-4 and S-9 cathode sensitivity of the photomultipliers commonly used yields increased quantum-efficiency of the light collected.

The process of successive energy transfers among the various constituents of the solution, even though clear in its main features, is still discussed in its details among different investigators (*2*). Since, according to several authors, the spectral distribution of the luminescence produced is independent of any particular way of excitation (*3, 4*), fluorescence (under ultraviolet irradiation) and scintillation (under gamma-ray or particle bombardment) should both be identical phenomena, insofar as ultimate light production is concerned. Thus, better insight into the energy-transfer mechanism might be gained by directly exciting—through selected narrow bands of ultraviolet light—different constituents of the mixture in succession (*5*). This affords a possibility to examine the processes involved (degradation, quenching, energy

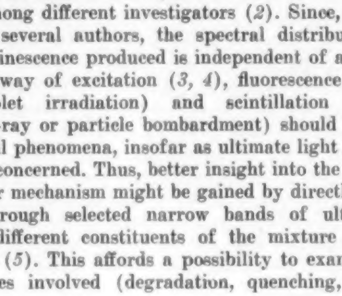

Fig. 1. Emission spectra (under gamma-ray bombardment of Co^{60}) of (*A*) *m*-xylene with 3 g/lit *p*-terphenyl; (*B*) *m*-xylene with 3 g/lit *p*-terphenyl and 10 mg/lit diphenylhexatriene; (*C*) *m*-xylene with 3 g/lit *p*-terphenyl and trace of diphenylhexatriene. A lucite cell (1 in. long) containing the solutions was placed in front of the slit of a Bausch & Lomb quartz monochromator and the spectral distribution was measured with an RCA-C7151 photomultiplier. The spectra (normalized to equal total intensity) show a complete shift in the spectral distribution from the primary to the secondary phosphor at the (optimal) concentration corresponding to case (*B*).

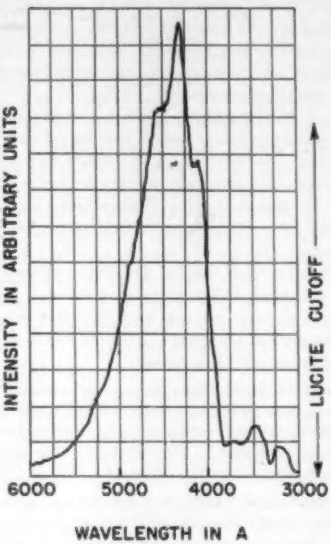

Fig. 2. Emission spectrum (under irradiation with ultraviolet light) of *m*-xylene with 3 g/lit *p*-terphenyl and 10 mg/lit diphenylhexatriene. A lucite cell containing the solution was placed in front of the slit of a Bausch & Lomb quartz monochromator and illuminated by a Hanovia hydrogen discharge tube in such a way that little direct light from the source could be recorded (absence of typical H-lines, as seen in Fig. 3). The shift is seen to be similar to the one obtained under gamma-ray bombardment, with a negligible amount of the *p*-terphenyl peak remaining.

transfer, and so forth) at each stage separately, greatly reducing therefore the complication of all these factors taken at once.

However, it has been pointed out recently that the fundamental identity of all the luminescent phenomena generally assumed might fail to be upheld by experiment. Although under radioactive excitation a complete shift of the original spectrum is observed on addition of a second solute phosphor (in a crystalline, plastic or liquid mixture) (*6*), for ultraviolet irradiation no such total shift could be detected in a recent experiment (*7*). Toluene containing $10^{-4}M$ of alphanaphtylphenyloxazole (ANPO) and *p*-terphenyl in concentrations ranging from $10^{-2}M$ to $10^{-3}M$ was used. The characteristic peak of the ANPO waveshifter shows up at $\lambda = 4150$ A, while the whole spectral distribution of *p*-terphenyl persists with somewhat diminished intensity (depending on the relative concentration of both phosphors).

Other investigations, on the contrary, rather seem to indicate a fundamental identity of the light-producing mechanism in both cases (*4*), even though the scintillation process in its entirety is vastly more complicated—and somewhat lengthened (*8*)—by many direct and indirect effects connected with the nature of radioactive bombardment (higher excited states, chemical dissociation, electric fields, mutual perturbation by neighboring excited and ionized molecules, and so forth) (*9*).

Measurements that I made (*10*) on double solute phosphors also show a complete spectral shift, thus supporting the view that both luminescent processes (scintillation and fluorescence) are identical phenomena. Both emission and absorption spectra were investigated. A Bausch & Lomb quartz monochromator was used. The spectral distribution was taken with an ultraviolet-sensitive photomultiplier (RCA-C7151) and traced out on a Brown Electronik recorder. For the emission spectra a lucite cell (1 in. long) containing the solutions (*m*-xylene with 3 g/lit *p*-terphenyl and 10 mg/lit diphenylhexatriene) was placed in front of the slit of the monochromator. For the absorption measurements, a lucite cell (2 in. long) was placed between the monochromator and the photomultiplier. A 20-mc Co^{60} gamma-ray source and a Hanovia hydrogen discharge tube were used to produce the excitation of the phosphors.

It is seen from the results, shown in Figs. 1, 2, and 3, that the characteristic features of the spectra under light and gamma-ray excitation appear to be nearly identical.

It has to be pointed out, however, that no exact quantitative comparison for transfer efficiency and light yield of different solutions under radioactive bombardment and ultraviolet excitation can be drawn

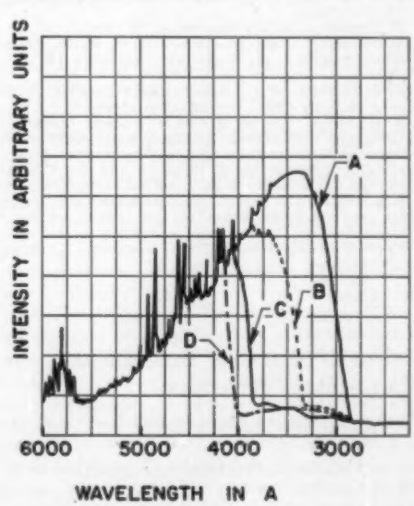

Fig. 3. Transmission spectra of ultraviolet light (Hanovia hydrogen discharge tube) through a lucite cell (2 in. long) placed between a Bausch & Lomb quartz monochromator and a recording RCA-C7151 photomultiplier: (*A*) lucite cell empty; (*B*) lucite cell filled with *m*-xylene and 3 g/lit *p*-terphenyl; (*C*) lucite cell filled with *m*-xylene and 3 g/lit *p*-terphenyl with a trace of diphenylhexatriene; (*D*) lucite cell filled with *m*-xylene, 3 g/lit *p*-terphenyl and 10 mg/lit diphenylhexatriene. The spectra have been normalized to equal differential intensity.

from the curves, since (i) no correction has been applied for the varying sensitivity of the photomultiplier at different wavelengths; (ii) the curves have been recorded under different monochromator slit widths and photomultiplier voltages.

However, they show, quite adequately, that for the optimal concentration of solutes, as commonly used, a rather complete shift to the spectrum of the secondary phosphor seems to occur, independently of the particular way the luminescence in the liquid is excited.

I am not prepared, at present, to determine the possible origin of the discrepancies observed in spectral shifts produced by second solutes in liquid scintillators.

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* Present address: Universidade Catolica, Rio de Janeiro, Brazil.
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10. This investigation was assisted by the joint program of the U.S. Office of Naval Research and the U.S. Atomic Energy Commission. I am indebted to the National Research Council of Brazil (Conselho Nacional de Pesquisas) for granting a fellowship. Sincere thanks are due to R. Hofstadter for his continuous interest in the work and to W. Van Sciver for valuable assistance in taking the spectrograms.

11 March 1955.

Value of a "Negative" Experiment in Extrasensory Perception

When is a negative result of sufficient value to warrant publication in *Science*? This question is raised by the report of Smith and Canon (*1*) on what they considered to be an experiment in extrasensory perception (ESP). After giving an ESP test to psychology students, they obtained results attributable to chance, results which therefore provided no evidence of ESP. The wording of the report implied an important bearing on earlier positive ESP results. It is an important question for research in general whether such a negative report has any generalization value.

Failure to confirm previous reported results is an important finding when the essential conditions are replicated. Such exact replication is seldom attainable in a field so complicated with uncontrolled variables as psychology. In addition, Smith and Canon did not even pretend to replicate any previous research; there was almost no similarity to any experiment that has yielded positive results on ESP.

ESP is recognizably difficult to demonstrate, and no one claims to know how it can be reliably produced on demand. The phychological conditions essential to its functioning are only slowly emerging from the studies of recent years. Under such circumstances, failure to approximate previous results may have no significance.

The Smith and Canon experiment was, unfortunately, not well designed as a research in ESP. The problem was new to the authors, and when Canon wrote me about his plan I replied with a four-page analysis from which I quote:

> Merely to carry through your experiment as it is designed and get the chance results that I should expect you to get would not prove anything except just to add another confirmation of the wrong way to approach an unfamiliar field.

One of the faults I indicated lay in the curious device of making all the targets (or stimuli) to be identified by the subject *of one kind*—an unnecessary deception that went against all rational expectation on the part of the participating subjects. Another grave error lay in the unpsychological disregard of the elusive character of ESP and of the special need, therefore, to provide the test participant with conditions known to be favorable to the demonstration of the ability.

Naturally, I offered to help Canon to design a better experiment. One of the suggestions made was that he first become acquainted with what had already been learned about how to stimulate subjects to perform most effectively in controlled ESP tests. Emphasis was laid on the need for arousing strong interest or motivation. A warning was also given on a statistical handicap in his design, one that involved the risk of a serious "stacking error" when the same target sheet is used in testing a large number of subjects.

In any case, no single negative experiment could be important today against the vast accumulation of positive evidence for ESP in the 18 volumes of the *Journal of Parapsychology* and elsewhere. Such an experiment proves nothing about such researches as, for example, the well-known Pratt-Woodruff (*2*) or the Soal-Goldney (*3*)ESP series. However, it *is* important for the future of any branch of science that the standards of evidence be as strict in *criticism* of new findings that conflict with old ways of thinking as in the *establishment* of such new findings.

J. B. RHINE

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Duke University, Durham, North Carolina

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28 March 1955

Organizing Scientists To Meet a National Emergency

While we continue to strive for a world at peace, we shall have reason to protect ourselves against a sudden attack as long as the cold war continues. Most experts feel that a future war would be sudden and swift and that it would provide us with little time for preparation. How then can America meet such an emergency? It is clear that we must maintain our traditional "minute-man" philosophy and that each one must do his part to defend the nation. Each one of us must carry on his usual civilian functions, but at the same time he must be trained to take his part within a matter of hours in support of the national defense.

Because of the threat of hydrogen bombs, guided missiles, bacteriological warfare, and other highly technical super-weapons, the scientists must play a major role in any future war. They would be used in many capacities, for example (i) to guide the civil defense; (ii) to maintain industrial production (*1*); (iii) to assist the military in tactical operations; (iv) to serve as operational research observers; (v) to invent radically new types of weapons and improve older ones; and (vi) to perform scientific counterintelligence. Each scientist and technologist has a very specific area of proficiency that he has developed through years of specialized training. If scientists and technologists are to be used to the best possible advantage in national defense, each one must be assigned to a special emergency function, and steps must be taken to train him for the job that he would assume in time of danger. At the present time there is so much emphasis on military research that in time of emergency there would be little need to augment the existing number of scientists working on weapons.

However, the fact that a large number of scientists are now associated with military research and development programs does not mean that these scientists are ready to tackle emergency assignments. How many of these scientists would know, for example, what percentage of radioactive cobalt would make water unsafe for drinking? As a matter of fact, how many would be able to tell that the radioactivity of the water was caused by cobalt? How many of the men associated with our present civilian defense agencies could detect the presence of deadly plutonium deposits whose alpha particles do not affect a standard Geiger counter? How many of our civilian defense personnel could identify a virus, tell whether it is harmful to human beings, animals, or plants, and determine the proper countermeasures? Our state of utter unpreparedness makes me shudder. And when I am told by a high official of the Department of Defense that there is no need for further preparation, I feel called upon to present my point of view to the public (*2*).

As a possible mode of implementation, I suggest that a civilian-directed scientists corps be set up within the Department of Defense as soon as possible to organize the scientists of the country to prepare us for an emergency. By the term *scientist* I naturally mean to include all research engineers and technologists. The Secretary of Defense would determine by operational analysis studies how many scientists would be needed to perform each type of function. With the help of the National Academy of Sciences, echelons of personnel could be established so that each individual scientist would be assigned to a specific emergency job.

Once this assignment had been made and accepted on a voluntary basis, the problem of training and preparing the scientist to perform his emergency assignment would begin. Each individual might be expected to spend 1 or 2 weeks a year working full time with other members of his division; to take specialized training courses at the level of university graduate schools; and to participate whenever possible in monthly or bimonthly evening lectures on appropriate scientific military topics (*3*). The scientists corps would have no need for the stringent physical requirements of the armed services, for an older man or a man with physical defects might still function efficiently as a scientist. A few scientists might wish to make a career out of scientific corps work, and there would definitely be need for such men to comprise a permanent skeleton organization. In order to assist in this training program, there is need for (i) good textbooks (at an advanced level) on theory and practice in each of the areas of interest; (ii) graduate and correspondence courses having appropriate subject matter, and (iii) a postgraduate university of scientific technology.

It would be desirable from many standpoints for the scientists corps to be a branch of the Department of Defense but completely distinct from the Army, Navy, and Air Force. At the present time there are a number of such specialist corps within the military establishment: the Corps of Engineers, Signal Corps, Medical Corps, Dental Corps, Veterinary Corps, Chemical Corps, and so forth. However, it might be better for the scientists corps to have a setup more nearly like that of the Coast Guard, which is half-civilian in character. The Coast Guard is a branch of the Department of the Treasury; its employees have civil service ratings, but at the same time they are members of the Naval Reserve. Thus the Coast Guard can function in peacetime as a purely civilian organization, but in time of emergency it can become as military as the occasion demands. In any case, the scientists should be able to work without the constraints of a military organization, and yet they should be accorded the privileges and treatment of officers. Individuals within the scientists corps could be designated as scientist I, II, III, and so forth, to indicate their status and to serve as a guide to their equivalent military rank. During World War II, the OSRD was amazingly successful in organizing the scientists to assist in the national defense, and I hope that the scientists corps would have many of the characteristics of the OSRD. Members of the scientists corps could be assigned to work with military units, and the scientists corps would endeavor to help the Army, Navy, and Air Force (*4*).

Through the medium of the scientists corps, it

should be possible to develop a satisfactory solution for the obligations that young scientists, engineers, and technologists owe to the national defense and are now imposed upon them by the Selective Service System. Within the universities, I would hope that the R.O.T.C. would expand its excellent curriculum to include a branch designed to train young scientists, as scientists, in the sorts of military technology that they should know in order to be of service in time of emergency. If such scientist training courses cannot be set up within the framework of the R.O.T.C., then it would be desirable for the scientists corps to organize such a program parallel to the present R.O.T.C. program. On the basis of enrollment in such a program, the young scientist could ask his local draft board for temporary deferment. Furthermore, this specialized R.O.T.C. training would qualify the student on graduation for a commission as second lieutenant or ensign, and he would be assigned for a 2-year period to such duty as the scientists corps directs.

The scientists corps might assign him to a specialized training course in a university, leading toward an advanced degree, or it might assign him to duty in a military base, depending on whatever appears to be in the best interest of the country. In any case, the scientist would be assigned some specific emergency function, and he would be required to prepare himself accordingly.

Thus, instead of asking for draft deferment, exemption, and release from patriotic obligations for our scientists, we seek their better utilization. As a matter of fact, the scientists of the country have no argument at the present time with the Selective Service System, which has attempted to carry out the mandates of the people in a democratic fashion. Instead, the scientists are worried about the malassignments of many of the technically trained personnel after their induction (*5*). The principal difficulty that prevents the proper utilization of technically trained draftees is that most government laboratories, including those operated by the Army, Navy, and Air Force, are strictly civilian and have no provision for supervising, disciplining, and housing enlisted personnel.

For example, a scientist inductee cannot at the present time be sent to Los Alamos to work on atomic or hydrogen bombs. If, however, the Armed Forces could order some of its scientist inductees and reserve officers to work in a civilian capacity in government laboratories or to take courses of specialized training within our universities, these men would be able to strengthen the military potential far more than they could if they were assigned such jobs as driving dump trucks, standing guard duty, or doing "squads left." At the same time that the Army, Navy, and Air Force are hiring large numbers of civilian scientists to man their laboratories, they are wasting the scientific potentials of many of the men who come within their jurisdiction. We simply do not have the technically trained manpower to waste in this manner when we are trying to set up an adequate system of national defense.

President Eisenhower's plan that 100,000 specially qualified young men be inducted each year for 6 months of active training followed by 9 years of service in the reserves should fit in very well with my proposal. The scientists corps would serve as the reserve unit for these men. The Eisenhower plan would be even more ideal if it were possible to break up the 6-month period of active duty into two 3-month summer periods, in which case there would not be any interference with the young man's educational program.

I do not feel competent to discuss the organizational details of the scientists corps. A high-level joint civilian-military committee should be set up to determine such matters. A great many conflicting interests must be considered, and especially the overlapping of the scientists corps with existing agencies. However, if the serious need for the preparation of our scientific manpower to meet a national emergency is recognized, a high-level civilian-military committee can certainly discover the best ways and means for accomplishing this objective. Our national security depends upon its success.

JOSEPH O. HIRSCHFELDER

Naval Research Laboratory,
University of Wisconsin, Madison

References and Notes

1. Since strategic bombing will play a major role in a future war, and since our country as well as the enemy's will be the victim of such attacks, the maintenance of industrial production may be the key to our survival. The improvising of processes when the usual materials are not available, and the rebuilding of industrial plants, would become extremely important in such a emergency.
2. This article is based on an address presented 10 Feb. 1955 at the Military-Industrial Conference of the Society of American Military Engineers, Chicago, Ill.
3. The present bimonthly meetings of the technical Reserve Officers units are of the right type. However, such meetings should be improved in character by providing funds for visiting speakers, by distributing motion pictures of new military scientific developments, and by making a real effort to establish interesting programs.
4. The problems of scientists working within a military organization are nicely summarized in the Riehlman Report of the Military Operations Subcommittee of the House Government Operations Committee and are very clearly stated by Lloyd V. Berkner in Appendix J of that report [House Rept. 2618 (4 Aug. 1954)].
5. The military services are making an effort to determine the specialized training of inductees and officers and give them a suitable assignment. However, the military organizations are so complicated that it is difficult to pass the information regarding a particular individual's qualifications to a particular military group that happens to need an individual with a specialized training. Maj. Gen. Leslie E. Simon, assistant chief of Army Ordnance, deserves a great deal of credit for making a serious effort to place technically qualified inductees in the proper positions in the laboratories and arsenals under his jurisdiction. Each month he prepares and distributes a mimeographed list of all of the technically trained inductees that he hears about. Groups having need for particular individuals make a check mark on this list and return it to Simon. He then makes a serious effort to have these persons transferred to the appropriate positions at the end of their basic training. However, Simon has difficulty in learning of the existence of these individuals. The Office of Naval Research is doing an excellent job placing technically trained reserve Naval officers in appropriate jobs. I also understand that Maj. Gen. William N. Creasey is doing a very good job in the placement of chemists and chemical engineers in the Chemical Corps. Individual efforts such as these should be encouraged.

25 March 1955.

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SCIENCE

Age and Leadership

THE relationship of age to leadership was an important implication of the recent conference sponsored by the National Institute of Mental Health and the American Psychological Association to consider the direction of further research on the psychological aspects of aging. Issues involving this relationship will acquire increasing importance as the full impact of new developments in science, education, and industry is realized. Certainly much of national policy, and perhaps of progress, is dependent on our obtaining definitive answers to a number of questions that hinge on values associated with aging and the retention of skills.

In this country a large proportion of the high executive and administrative positions are held by older men. There are, however, numerous instances of the appointment of a young man to an administrative post on the basis of his outstanding achievement, his capacity to generate fresh ideas, and his energy to put them into practice. I sometimes question the wisdom of rewarding a young man for a valuable contribution with an administrative position that demands all his attention and shortens the "doing" stage of his career. Comprehensive studies indicate that the novel and significant ideas are developed early by men who stay within one career; the later years, in contrast, seem to extend, exploit, and bring to fruition many of the earlier patterns of thought. For most men of ideas, there appears to be a progression toward maturity and leadership. If this is the case, then the shortening of the period for the kind of work in which novel ideas develop is not the ideal way to cultivate creativity.

A mature leader is generally a constructive person who has experienced the various development phases. His goals are clear, his thinking is realistic. A mature leader also recognizes the value and the difference between his job responsibilities and those of younger workers. Hence, the working climate under such a person is generally very wholesome. He cultivates the talents of his group and, in turn, graciously accepts their support. When crises arise, they are met with a minimum amount of overreaction and contagious disturbance.

Much of the popular thinking about the deterioration of abilities with age simply does not rest on established fact. Many older workers who have maintained an active interest in a subject for many years are able to draw on an accumulation of personal knowledge and experience, which is not a part of the background of the younger worker.

Our national mental health goal is the maximum number of healthy, happy, and informed individuals of every age. It is urgent that facts about mental abilities, personality, and physical fitness be considered in defining retirement policies and in making appointments in the higher occupational levels of science, government, and industry.

Older people are often defensive about the subject of creativity and age. By encouraging objective discussion of age and leadership, we can overcome a major barrier to the development of our national maturity as well as individual maturity. Free and unhampered discussion will strengthen research in those areas of the biological and social sciences where much basic information is still lacking. Together, these may be the avenues by which more elderly people can achieve a successful old age that will mean not only greater satisfactions to the individual person but an enrichment of the country as a whole.

R. H. FELIX, *director*
National Institute of Mental Health,
National Institutes of Health,
U.S. Public Health Service

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Meetings & Conferences

June

29–1. National Science Teachers Assoc., science conf., Madison, Wisc. (R. H. Carleton, NSTA, 1201 16 St., NW, Washington 6.)

30–2. Acoustical Soc. of America, State College, Pa. (W. Waterfall, ASA, 57 E. 55 St., New York 22, N.Y.)

July

2–4. Astronomical League, Seattle, Wash. (G. C. Scholz, 166 Mason Hall Apts., Alexandria, Va.)

3–9. American Library Assoc., annual, Philadelphia, Pa. (D. H. Clift, 50 E. Huron St., Chicago 11, Ill.)

4–8. International Conf. of the Biometric Soc., São Paulo, Brazil. (W. G. Cochran, Johns Hopkins Univ., Baltimore, Md.)

4–8. International Diabetes Federation, Cambridge, Eng. (IDF, 152 Harley St., London, W.1.)

4–9. South African Assoc. for the Advancement of Science, annual congress, Grahamstown, S. Africa. (B. T. Davie, Box 6894, Johannesburg.)

7–11. International Symposium on Molecular Spectroscopy, Oxford, Eng. (H. W. Thompson, St. John's College, Oxford.)

11–17. International Symposium on General Relativity, Bern, Switzerland. (H. A. Barton, International Union of Pure and Applied Physics, 57 E. 55 St., New York 22.)

13–17. International Seaweed Symposium, 2nd, Trondheim, Norway. (ISS, c/o T. Braarud, Blindern, Oslo.)

15–22. Assoc. Française pour l'Avancement des Sciences, Caen, France. (Mlle. Henri-Martin, Secrétaire, 28 rue Serpente, Paris 6e.)

18–23. International Assoc. of Applied Psychology, London, England. (C. B. Frisby, Natl. Inst. of Industrial Psychology, 14 Welebeck St., London, W. 1.)

18–23. International Water Supply Cong., 3rd, London, Eng. (L. Millis, 34 Park St., London, W.1.)

20–28. International Union of Pure and Applied Chemistry, Zurich, Switzerland. (R. Morf, Sec. Gen., IUPAC, Zurich 1.)

23–29. International Soc. of Surgery, 16th cong., Copenhagen, Denmark. (E. A. Graham, 600 S. Kingshighway, St. Louis, Mo.)

25–30. International Anatomical Cong., Paris, France. (G. Cordier, 3 Square Alboni, Paris 16e.)

26–29. American Malacological Union, Staten Island, N. Y. (Mrs. M. C. Teskey, P.O. Box 238, Marinette, Wis.)

28–30. Colloquium on Biochemical Problems of Lipids, 2nd, Univ. of Ghent, Belgium. (R. Ruyssen, St. Jansvest 12, University of Ghent, Belgium.)

August

1–5. International Cong. of Plastic Surgery, Stockholm and Uppsala, Sweden. (J. F. Larsen, 12, Kristianiagade, Copenhagen Ø, Denmark.)

1–6. International Cong. of Biochemistry, Brussels, Belgium. (C. Liebecq, 17 Place Delcour, Liége, Belgium.)

3–7. International Meeting of Neurobiologists, Groningen, Netherlands. (J. A. Kappers, Dept. of Anatomy and Embryology, Oostersingel 69, Groningen.)

5–6. Pennsylvania Academy of Science, University Park, Pa. (K. Dearolf, Public Museum and Art Gallery, Reading, Pa.)

(See issue of 20 May for more comprehensive listings.)

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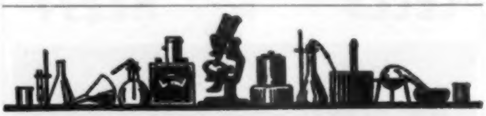

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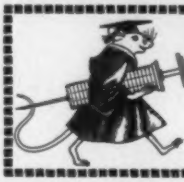

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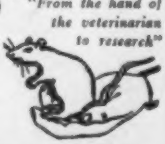

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